THE

GEOGRAPHY OF THE HEAVENS,

AND

CLASS BOOK OF ASTRONOMY,

ACCOMPANIED BY

A CELESTIAL ATLAS.

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REVISED AND CORRECTED

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TABLE OF CONTENTS.

PREFACE

TO THE FIRST EDITION.

I HAVE long felt the want of a Class Book, which should be to the starry heavens, what Geography is to the earth; a work that should exhibit, by means of appropriate delineations, the scenery of the heavens, the various constellations arranged in their order, point out and classify the principal stars, according to their magnitudes and places, and be accompanied at the same time, with such familiar exercises and illustrations, adapted to recitation, as should bring it within the pale of popular instruction, and the scope of juvenile understandings.

Such a work I have attempted to supply. I have endeavored to make the descriptions of the stars so familiar, and the instructions for finding them so plain, that the most inexperienced should not fail to understand them. In accomplishing this, I have relied but little upon globes and maps, or books. I very early discovered that it was an easy matter to sit down by a celestial globe, and, by means of an approved catalogue, and the help of a little graduated slip of brass, make out, in detail, a minute description of the stars, and discourse quite familiarly of their position, magnitude and arrangement, and that when all this was done, I had indeed given the pupil a few additional facilities for finding those stars upon the artificial globe, but which left him, after all, about as ignorant of their apparent situation in the heavens, as before. I came, at length, to the conclusion, that any description of the stars, to be practically useful, must be made from a careful observation of the stars themselves, and made at the time of observation.

To be convinced of this, let any person sit down to a celestial globe or map, and from this alone, make out a set of instructions in regard to some favorite constellation, and then desire his pupil to trace out in the firmament, by means of it, the various stars which he has thus described. The pupil will find it little better than a fancy sketch. The bearings and distances, and especially, the comparative brightness, and relative positions, will rarely be exhibited with such accuracy that the young observer will be inspired with much confidence in his guide.

I have demonstrated to *myself*, at least, that the most judicious instructions to put on paper for the guide of the young in this study are those which I have used most successfully, while in a clear evening, without any chart but the firmament above, I have pointed out, with my finger, to a group of listeners, the various stars which compose this and that constellation.

In this way, the teacher will describe the stars as they actually appear to the pupil — taking advantage of those obvious and more striking features that serve to identify and to distinguish them from all others. Now, if these verbal instructions be committed to writing, and placed in the hands of any other pupil, they will answer nearly the same end. This is the method which I have pursued in this work. The descriptive part of it, at least, was not composed by the light of the sun, principally, nor of a lamp, but by the light of the stars themselves. Having fixed upon the most conspicuous star, or group of stars, in each constellation, as it passed the meridian, and with a pencil carefully noted all the identifying circumstances of position, bearing, brightness, number and distance — their geometrical allocation, if any, and such other descriptive features as seemed most worthy of notice, I then returned to my room to transcribe and classify these memoranda in their proper order; repeating the same observations at different hours the same evening, and on other evenings at various periods, for *a succession of years;* always adding such emendations as subsequent observations matured. To satisfy myself of the applicability of these descriptions, I have given detached portions of them to different pupils, and sent them out to find the stars; and I have generally had the gratification of hearing them report, that "every thing was just as I had described it." If a pupil found any difficulty in recognizing a star, I re-examined the description to see if it could be made better, and when I found it susceptible of improvement, it was made on the spot. It is not pretended, however, that there is not yet much room for improvement; for whoever undertakes to delineate or describe every visible star in the heavens, assumes a task, in the accomplishment of which he may well claim some indulgence.

PREFACE

TO MITCHEL'S EDITION.

THE extraordinary discoveries which have marked the History of Astronomy, during the last few years, demand corresponding changes in the books designed for the instruction of those who seek a knowledge of this science. Feeling confident that nothing can be more important, than the furnishing of our schools with valuable elementary works in science, I have been induced to undertake the revision and the re-writing of a large part of the well known school book, *The Geography of the Heavens*. In consequence of the rapid advance in Astronomy, and the important change, which has recently commenced in our country, in the mode of prosecuting its study, this revision has become absolutely necessary. When this work first appeared there were very few telescopes in the United States, and of these a very small proportion were employed in the schools and academies, as means of instruction. Hence, at that time, any description of the telescopic objects, found within the limits of the several constellations, would have been almost useless. Within the last six years a new era in Astronomical science has dawned on our country. A zeal and ardor has been aroused in its behalf, which, at one time, was regarded as quite impossible, in consequence of the peculiar nature of our government and institutions. The reproach cast upon us by Europeans, for our utter neglect of science, if ever just, is no longer so. Only a few years have passed, since the first effort was made to arouse the American people to the importance of the cultivation of Astronomical science, and we now are able to point to no less than three first class observatories, all erected within the last five years, at points widely distant from each other. The example thus set in the West and the East, has prompted to active effort in many parts of our country, and, at this time, there is scarcely a school or college of any rank, at which it has not been resolved to attempt the founding of an Astronomical Observatory, of greater or less magnitude. To meet these rapid changes in the mode of conveying the truths of Astronomy, and to present, in simple and intelligible form, the results of the recent important discoveries, will be the main objects of attention in the revision of this work.

A large part of the Mythological notices will be omitted, as less important than the description of telescopic objects found in the various constellations. These objects, consisting of nebulæ, clusters, double, triple, multiple and binary stars, rich fields and vacant spots, will be noticed, and described, their places given, and drawings of the more important objects, with a note of the diameter of the object glass which will show them, and render their observation possible.

Among the new topics treated, we may notice the following as some of the more important.

The subject of the binary and double stars, their distances and periods of revolution, has engaged the attention and talent of many of the best Astronomers of the world, for the last twenty years. These revolving suns will be found to fill their appropriate places in the revised work. The enlarging of the limits of the solar system, by the discovery of a planet exterior to Uranus, the extraordinary means of its discovery, its subsequent history, and the elements of its orbit, constitute a topic of deep interest; add to this the discovery of five new asteroids, within the last two years, and the perfection of the tables of all the old planets, and we find most important advances in our knowledge of the solar system.

In the structure of the Sidereal Heavens, and our knowledge of the distribution of the stars in space, little had been done after the death of Sir W. Herschel, until within the last few years. The discovery of the actual distance of a fixed star, by Bessel, gave a new impulse to the investigation of these sublime subjects. This triumph of Bessel was speedily followed by many others, of a like kind. M. Argelander demonstrates the motion of the sun and solar system in space, and fixes the point towards which it is moving; M. Otho Strüve determines its annual angular motion as seen from the fixed stars of the first magnitude; and, finally, M. Peters, of Russia, fixes the distance of the stars of the second magnitude, from the mean parallax of some thirty stars, deduced from observation. With these data, and the preceding investigations of Sir W. Herschel, M. Strüve, of Pulkova, Russia, commences a discussion of the distribution of the stars in space; the populousness of the Milky Way and the heavens, generally, in stars; determines the relative distances of the spheres of the fixed stars of the different magnitudes; and, finally, their absolute distances, and the actual velocity of the sun and solar system through space. If we add to these topics the discoveries by Lord Rosse's great reflector, the changes in the views hitherto entertained on the subject of La Place's nebular hypothesis, and Mädler's theory of the great central sun, we find that the last few years have been the most wonderful, and the most fruitful, in the whole history of Astronomy since the time of Newton.

The necessity of a new edition of the Geography of the Heavens need not be urged, after what has been said. To meet the demands, a new set of star charts have been prepared expressly for this work, and the text will be found to conform to these charts.

MOUNT ADAMS, May 1st, 1848.

THE REVISED

GEOGRAPHY OF THE HEAVENS.

PRELIMINARY CHAPTER.

The phenomena of the heavens have excited the curiosity, and fixed the attention, of mankind, in all ages of the world. The beautiful clustering of the bright stars, the moving planets, the extraordinary changes of the moon, the phenomena of the day and night, were themes for study at a period so remote, that neither history nor tradition reach far enough back in the past, to tell us when or by whom, these researches were commenced, or prosecuted. From the earliest ages, down to the present time, the science of astronomy has presented problems, taxing the highest powers of the human intellect, and requiring for their solution the most profound reasoning, the most accurate observation, the most powerful instruments, and an ardor, perseverance and devotion, which have signalized human effort in no other department of scientific research. "The heavens declare the glory of God," and the successful examination of these same heavens, has most perfectly demonstrated that other great truth, that man has been made "but a little lower than the angels." By the effort of his genius, he has risen to a knowledge of the structure and laws of the universe, he has vindicated the wisdom of God, in the beautiful adjustments of the moving planets, and the harmonious revolutions of a multitude of worlds, linked together by a mysterious bond. He has extended the dominion of law to the remote stars, and has computed the periods of these far distant orbs. But these sublime results have not been obtained by any single individual, or by any one nation. The great problem of the universe has been given to the human race, and its solution has been the progressive work of all nations, in all ages, for the last six or seven thousand years. At the end of this vast period, we gather the fruits of all preceding effort, and condense into narrow limits that knowledge, to gain which, has required the highest intellectual activity of the best minds which have adorned the earth.

In looking out, of a clear night, on the starry heavens, we find a multitude of brilliant objects, scattered over the sky, without any law or order in their distribution. We readily remark a great difference in the brilliancy of the stars, and our attention is soon fixed upon certain groups of brighter objects, whose configurations, or relative positions, enable us to find them, readily, when they are in the visible heavens. The diversity in brightness has occasioned the classification of the stars, in order of their brilliancy. The brightest occupy the first class, and are called *stars of the first magnitude*. Of these there are only a few. From the brightest stars down to those just visible to the naked eye, the scale has been so divided that it comprehends *six magnitudes*, the number of stars in each class increasing as the brightness of the class decreases. We have six magnitudes visible to the naked eye, and then the telescopic stars carry the series down to the sixteenth magnitude, and even still lower. In the description of any star, then, we must always give its magnitude, as one means of fixing its identity. But as there are many stars in each class, the magnitude, alone, would not serve to point out a particular star. In the early ages of astronomy, the heavens were divided into certain subdivisions, or groups of stars, called *constellations;* and the figure of some animal, or other object, was assigned, whose outline would embrace all the stars in a given constellation. These subdivisions have been retained in modern times, and although attended with many inconveniences, they are too firmly fixed, and too intimately woven, in all works on astronomy, ever to be changed.

There is no resemblance between the configuration of the stars, and the object, whose name is assigned to the group; yet when the limits of the constellation, as fixed by the outline of the object whose name it bears, becomes accurately known and laid down on maps, these subdivisions, or constellations of stars, greatly assist in obtaining a knowledge of the heavens. We may even identify a star, by knowing it is the brightest of a given constellation. To render it possible to designate the stars of each constellation, they have been named after the letters of the Greek alphabet, until these are exhausted, calling the brightest star after the first letter, and so on down. In case the number of letters is insufficient to give names to all the visible stars in a constellation, the Roman alphabet is called into use, and after this is exhausted, the Arabic characters, 1, 2, 3, &c., are employed. Thus we call the brightest star in the constellation of the Swan, α Cygni, or *Alpha of the Swan;* the next brightest in the same constellation is called β *Cygni*, or Beta of the Swan; *Cygnus* being the Latin for *Swan*, and *Cygni*, meaning *of the Swan*. The same is true of the other constellations, the Latin names being always retained in the designation of the stars.

If the constellations contained a very few stars, and those of marked difference of magnitude, this mode of designating them might be sufficient for their identification and description. But in consequence of the multitude of stars, and the difficulty of distinguishing them from each other by their magnitudes, it has become necessary to fix their positions in the heavens, as the places on the earth's surface are fixed by their longitude and latitude. The corresponding terms applied to heavenly bodies, are *right ascension* and *declination*, which terms we proceed to define.

To us the sun appears to move among the fixed stars, and in the course of one year to return again to the point of departure. If his track could be marked by leaving behind him a bright line of fire, this line would be found to be a circle traced out among the fixed stars, and this track of the sun is called the *ecliptic*.

There are two points in this track of especial interest, from the fact that on the days when the sun occupies them, the length of the day and night is exactly the same, each being twelve hours. These points, on the ecliptic or sun's track, are called the *equinoctial points*. The one through which the sun passes in the spring is called the *vernal equinox*, that occupied by the sun in autumn is called the *autumnal equinox*.

Each day and night the sun, and other heavenly bodies, appear to describe circles in the heavens, called *diurnal circles*. They are all parallel to each other. That diurnal circle described by the sun, at either equinox, is called the *celestial equator*, or the *equinoctial*. If the equinoctial could be marked by a line of fire in the heavens, it would be found to cut the sun's track, or the ecliptic, in two opposite points, which we have already called the *equinoctial points*. To fix the place of a star, or other heavenly body, it is referred to the *equinoctial*, or *celestial equator*. A star on the north side of the equinoctial is in *northern declination*, and one on the south side of the same circle is in *southern declination*. To measure the distance of any object in the heavens, north or south of the equator, an imaginary circle is drawn through the object perpendicular to the equator, and the distance measured on the circle thus drawn from the object to the equator is called its *declination*. Knowing the declination of a star, north or south of the equator, does not suffice to fix its place in the heavens. It only locates it on the circumference of a small circle parallel to the equator, and distant from it by an amount equal to the known declination of the object. To fix the exact point of the object on this small circle, it is only necessary to know how far the circle, drawn through the object and perpendicular to the equator, cuts the equator from the vernal equinox. This distance measured on the equator, from the vernal equinox round eastward, is called the *right ascension*. Any circle drawn through a heavenly body, and perpendicular to the equator, is called a *meridian*. That meridian which passes through equinoctial points, is called the *prime meridian*, or the equinoctial colure. Any star, or heavenly body, situated on the prime meridian, has no right ascension, or its right ascension is equal to zero. In case the equator be divided into twenty-four equal parts, and meridians be drawn through the points of division, these meridians are called *hour circles*. A heavenly body situated on the first hour circle, east of the vernal equinox, has *one* hour of right ascension; if it be on the second hour circle, east, it will have two hours of right ascension, and so round, through the twenty-four hours of right ascension to the vernal equinox again.

That point in the heavens, directly above us, in which a perpendicular to the surface of still water, carried upward, would pierce the celestial sphere, is called the *zenith*. If the same perpendicular be conceived to pass downward and pierce the lower hemisphere, the point of piercing is called the *nadir*. The circle perpendicular to the equator, and passing through the zenith of any place, is called the meridian of that place. All points on the earth's surface in the same longitude, will have the same meridian.

The instant when the vernal equinox reaches the meridian of any place on the earth's surface, is the beginning of the *sidereal day*, which terminates when the vernal equinox shall have passed entirely round and returned to the meridian again. A clock, or watch, so regulated as to mark 0 hours at the instant when the vernal equinox is on the meridian of a given place, and to mark the hours from 0 to twenty-four hours, is called a *sidereal* clock, and keeps *sidereal* time. It will be found that the right ascension (marked R. A.) of each object is given in this work. In case the right ascension of a star is 3 h. 12 m. 10 s., it tells us that it will reach the meridian 3 h. 12 m. 10 s. after the vernal equinox has passed it. If the time, as shown by a sidereal clock, is *less* than the R. A. of a star, then the star has not yet reached the meridian; on the contrary, should the time indicated by the sidereal clock be greater than the R. A. of any object, then the object has already passed the meridian, and is *west* of it by an amount equal to the difference between the sidereal time and the R. A. To render this clear, take the following examples.

The R. A. of a star is 4 h. 26 m. 10 s., the sidereal time is 3 h. 15 m. 25 s. Is the star east or west of the meridian? It is *east* of the meridian, and to find the amount by which it is east,

	H.	M.	S.	
From the R. A. =	4	26	10	
Subtract	3	15	25	the time.
Diff. =	1	10	45	

In case the sidereal time is 5 h. 12 m. 20 s., then the star has already passed the meridian, and is west by an amount found as follows:

	H.	M.	S.
From the time =	5	12	20
Subtract the A. R. =	4	26	10
Diff. =	0	46	10

Or the star is 0 h. 46 m. 10 s. west of the meridian. Any one possessing a sidereal time piece, whether clock or chronometer, will find no difficulty in fixing the place of a heavenly body, as to its angular distance east or west of the meridian, at any hour in the twenty-four. The declination of the object, shows its distance north or south of the equator, and combining the two, the A. R. and the Declination, we have the exact position of the object in question. It frequently happens that persons are not provided with sidereal time pieces, but may possess very good solar clocks, chronometers or watches. Mean solar time is reckoned from the instant, that the center of the mean sun (or one moving with the mean motion of the true sun), is on the meridian. It differs from sidereal time, by 3 m. 56.5554 s. in each twenty-four hours, or a sidereal clock gains that amount daily on a mean solar clock. Hence we perceive that mean solar and sidereal time seldom, if ever, agree. When any heavenly body is on the meridian of a given place, a well regulated sidereal clock will show the *time* exactly equal to the *right ascension* of the body. No such relation exists between *mean solar time* and the *right ascension*.

To find the instant that an object, whose right ascension is given, reaches the meridian in mean solar time, or that shown by ordinary clocks and watches, the following table has been computed.

D's	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h m.	h. m	h. m.	h. m.	h. m
1	5 14	3 01	1 12	23 18	21 27	19 24	17 20	15 15	13 19	11 31	9 35	7 31
2	5 09	2 57	1 08	23 15	21 23	19 20	17 16	15 11	13 15	11 27	9 31	7 27
3	5 04	2 53	1 04	23 11	21 19	19 16	17 12	15 07	13 12	11 24	9 27	7 22
4	5 00	2 49	1 01	23 07	21 16	19 12	17 08	15 04	13 08	11 20	9 23	7 18
5	4 56	2 45	0 57	23 04	21 12	19 08	17 04	15 00	13 05	11 17	9 19	7 14
6	4 51	2 41	0 53	23 00	21 08	19 04	16 59	14 56	13 01	11 13	9 15	7 09
7	4 47	2 37	0 49	22 56	21 04	19 00	16 55	14 52	12 57	11 09	9 11	7 05
8	4 42	2 33	0 46	22 53	21 00	18 56	16 51	14 48	12 54	11 06	9 07	7 01
9	4 38	2 29	0 42	22 49	20 56	18 51	16 47	14 44	12 50	11 02	9 03	6 56
10	4 34	2 25	0 38	22 45	20 52	18 47	16 43	14 41	12 47	10 58	8 59	6 52
11	4 29	2 21	0 35	22 42	20 48	18 43	16 39	14 37	12 43	10 55	8 55	6 47
12	4 25	2 17	0 31	22 38	20 44	18 39	16 35	14 33	12 39	10 51	8 51	6 43
13	4 21	2 13	0 27	22 34	20 41	18 35	16 31	14 29	12 36	10 47	8 47	6 39
14	4 16	2 09	0 24	22 31	20 37	18 31	16 27	14 26	12 32	10 43	8 43	6 34
15	4 12	2 05	0 20	22 27	20 33	18 27	16 23	14 22	12 29	10 40	8 39	6 30
16	4 08	2 01	0 16	22 23	20 29	18 22	16 19	14 18	12 25	10 36	8 35	6 25
17	4 04	1 57	0 13	22 20	20 25	18 18	16 15	14 14	12 21	10 32	8 30	6 21
18	3 59	1 54	0 09	22 16	20 21	18 14	16 11	14 11	12 18	10 28	8 26	6 16
19	3 55	1 50	0 06	22 12	20 17	18 10	16 07	14 07	12 14	10 25	8 22	6 12
20	3 51	1 46	0 02	22 08	20 13	18 06	16 03	14 03	12 11	10 21	8 18	6 08
21	3 47	1 42	23 58	22 05	20 09	18 02	15 59	13 59	12 07	10 17	8 14	6 03
22	3 42	1 38	23 55	22 01	20 05	17 57	15 55	13 56	12 03	10 13	8 09	5 59
23	3 38	1 34	23 51	21 57	20 01	17 53	15 51	13 52	12 00	10 10	8 05	5 54
24	3 34	1 31	23 47	21 53	19 57	17 49	15 47	13 48	11 56	10 06	8 01	5 50
25	3 30	1 27	23 44	21 50	19 53	17 45	15 43	13 45	11 53	10 02	7 57	5 45
26	3 26	1 23	23 40	21 46	19 49	17 41	15 39	13 41	11 49	9 58	7 53	5 41
27	3 21	1 19	23 36	21 42	19 45	17 37	15 35	13 37	11 45	9 54	7 48	5 36
28	3 17	1 16	23 33	21 38	19 41	17 32	15 31	13 34	11 42	9 50	7 44	5 32
29	3 13	1 14	23 29	21 35	19 37	17 28	15 27	13 30	11 38	9 47	7 40	5 28
30	3 09	....	23 25	21 31	19 32	17 24	15 23	13 26	11 35	9 43	7 35	5 23
31	3 05	....	23 22	.....	19 28	.....	15 19	13 23	.....	9 39	....	5 19

A few examples will suffice to explain the use of this table.

Given the A. R. of Sirius = 6 h. 38 m. 07 s.—required the apparent time of its meridian passage, on January 11th.

RULE.—*To the number placed opposite the date, add the A. R. of the star, as found in this work.*

		H. M. S.
Thus:	A. R. of Sirius =	6 38 07
	Tabular No.	4 29 00
	Sum	11 07 08

Or Sirius passes the meridian at 11 h. 07 m. 08 s. *apparent* time.

EXAMPLE.—Required the apparent time of the meridian passage of *Vega*, on May 30th.

	H.	M.	S.
A. R. of Vega =	18	31	34
Tabular No. =	19	32	00
Sum =	38	03	34
* Subtract 24 hours	24	00	00
Meridian passage	14	03	34 apparent time.

It will be noticed that the foregoing computations have been made for *apparent* time. This is slightly different from the time shown by clocks and watches, called *mean* time. *Apparent* noon is the exact instant when the true sun's center is on the meridian. In consequence of the apparent irregular motion of the sun, there is a variable difference between *apparent* or *true time*, or that shown by the sun, and *mean time*, or that shown by the clock.

Since we rely for our time on the clock, we here present a table which will exhibit the mean days in the year, on which a clock or watch, regulated to mean time, will be an even number of minutes faster or slower than the sun.

From this table it is easy to reduce the *apparent time* of any meridian passage, found by the preceding table, to mean or clock time. To be rigidly accurate, the correction should be taken from the nautical almanac, or other accurate ephemeris, but for ordinary gazing these tables are quite sufficient.

* In case the sum produced by adding to the tabular number opposite the given date the A. R. of the star, or other heavenly body, be greater than twenty-four hours, from the sum subtract twenty-four hours, and the remainder will be the apparent time of meridian passage.

Days.	Cor. in min.	Days.	Cor. in min.	Days.	Cor. in min.	Days.	Cor. in min.	Days.	Cor. in min.	Days.	Cor. in min.
Jan. 2	4 F	Mar 12	10 F	May 1	3 S	Aug. 16	4 F	Sept. 27	9 S	Dec. 5	9 S
" 4	5 F	" 15	9 F	" 15	4 S	" 20	3 F	" 30	10 S	"	8 S
" 6	6 F	" 19	8 F	" 28	3 S	" 24	2 F	Oct. 3	11 S	" 10	7 S
" 11	8 F	" 22	7 F	June 5	2 S	" 28	1 F	" 6	12 S	" 12	6 S
" 14	9 F	" 25	6 F	" 11	1 S	Sept. 1	0	" 10	13 S	" 14	5 S
" 16	10 F	" 28	5 F	" 15	0	" 3	1 S	" 14	14 S	" 16	4 S
" 19	11 F	April 1	4 F	" 19	1 F	" 6	2 S	" 19	15 S	" 18	3 S
" 23	12 F	" 4	3 F	" 24	2 F	" 9	3 S	" 27	16 S	" 20	2 S
" 27	13 F	" 7	2 F	" 29	3 F	" 12	4 S	Nov. 16	15 S	" 22	1 S
Feb. 3	14 F	" 11	1 F	July 4	4 F	" 15	5 S	" 20	14 S	" 24	0
" 28	13 F	" 15	0	" 10	5 F	" 18	6 S	" 24	13 S	" 26	1 F
Mar. 4	12 F	" 19	1 S	" 21	6 F	" 21	7 S	" 27	12 S	" 28	2 F
" 8	11 F	" 24	2 S	Aug. 10	5 F	" 24	8 S	Dec. 3	10 S	" 30	3 F

Now, returning to the examples already given of the meridian passages of Sirius and Vega; the first of these stars was found to culminate or pass the meridian at 11 h. 07 m. 08 s. *apparent time*, on the 11th Jan. By the last table, on the 11th of January, the clock is 8 m. faster than the sun. Hence the culmination by the clock will take place at 10 h. 59 m. 08 s.

Again, Vega was found to culminate at 14 h. 03 m. 34 s., on the 30th May, apparent time. By the preceding table, on the 28th of May the clock was 3 m. slower than the sun, and gaining one minute in 7 days, or about 9 s. per day. On the 30th the clock will be slow, about 2 m. 42 s.; and hence Vega will culminate, by the clock, 14 h. 03 m. 34 s. + 2 m. 42 s. = 14 h. 06 m. 16 s.

These approximations are sufficiently accurate for ordinary purposes.

The first table will not be in error more than 1 m. for twenty years, when the stars will culminate about one minute *later* than shown by the table.

From all the foregoing considerations we deduce the following *definitions*:

The *magnitude* of a star is its brightness compared with any star assumed as a standard.

A star of the 1*st magnitude* is of the highest order of brightness.

All stars below the *6th magnitude* are only rendered visible by telescopic aid.

A *constellation*, is a group of stars falling within the limits of the outline of any animal or object whose name it bears, and whose figure is conceived to be drawn in the heavens, and is actually drawn on globes and maps of the heavens.

The *ecliptic*, is the path which the sun appears to describe in a year among the fixed stars.

The *equator* or the *equinoctial*, is a great circle cut from the heavens by producing the plane of the earth's equator to meet the celestial sphere. The *equinoxes* are the points in which the celestial equator and the ecliptic cut each other.

Diurnal circles, are those circles which the heavenly bodies appear to describe every twenty-four hours. They are all parallel to the equator.

Meridians, are great circles perpendicular to the celestial equator, and meeting in the points called the *north* and *south poles* of the heavens.

Hour circles, are meridians, cutting the equator so as to divide it into twenty-four equal parts; the first point of division being at the vernal equinox.

The *zenith*, is the point in which a perpendicular to the surface of still water, pierces the celestial sphere above.

The *nadir*, is where the same perpendicular pierces the celestial sphere below.

The *meridian of any place*, is the great circle, perpendicular to the celestial equator, and passing through the *zenith* of the place. The *right ascension* of a heavenly body, is its distance east of the *vernal equinox*, reckoned on the celestial equator.

The *declination* of a heavenly body, is its distance north or south of the equator, measured on a meridian passing through the heavenly body.

The declination is expressed in degrees, minutes and seconds, of a great circle, and is expressed by these symbols, ° ′ ″. Thus we write 12 degrees, 17 minutes, 10 seconds: 12° 17′ 10″.

A *sidereal day*, is the interval from the instant the vernal equinox is on the meridian of a given place, till it again reaches the same meridian.

A *true solar day*, is the interval from the instant the center of the true sun is on the meridian of a given place, till it again reaches the same meridian.

A *mean solar day*, is the interval from the instant that the center of an imaginary sun (moving with the mean daily motion of the true sun) is on the meridian of any given place, till it reaches again the meridian of the same place.

The *equinoctial colure*, is a meridian passing through the equinoctial points.

Parallels of declination, are small circles, north or south of the equator, and parallel to it.

The *rational horizon*, is a plane passing through the center of the earth, and perpendicular to the radius drawn to any place on the earth's surface. It divides the heavens into two hemispheres, the upper being the *visible*, the lower the *invisible* hemisphere.

Any heavenly body is in the act of *rising*, when it passes from below up through the plane of the *rational* horizon. It is *setting*, when in the act of passing below this same plane.

The *sensible* horizon, is the circle limiting our view, or where the earth and sky appear to meet.

Vertical circles, pass through the zenith, and perpendicular to the horizon.

The *prime vertical*, is the great circle, which cuts the horizon in the east and west points.

Before proceeding to an exploration of the heavens, it will be necessary to acquire some knowledge of the classes of objects, the individuals of which will be hereafter described. The most casual observer cannot fail, on the first examination of the heavens, to notice an irregular zone, of unequal brightness, called the *Milky Way*, which is seen to sweep entirely round the celestial sphere. This bright zone is found to consist of millions of stars, scattered with rich, but irregular profusion, throughout its entire extent. Nearly all its stars are below the sixth magnitude, and are, of course, invisible to the naked eye. But the smallest telescopic aid reveals multitudes of stars; and as the power of the telescope is increased, the number of stars brought to view increases in a like proportion. Although, according to the investigations of modern science (to be more fully examined hereafter), we may not fix absolute bounds and limits to the millions of stars composing the Milky Way, yet if we confine our examinations to the richer or denser portions, we are able to assign a figure within whose limits the Milky Way will be confined. Were it possible to enclose all the stars composing the Milky Way in some opaque envelope which would shut them out from all space beyond, within this envelope and not very far from its center, our own sun, itself a fixed star, would be found. Having thus enclosed the stars of the Milky Way in imagination, it is found that the space on the outside of this envelope is not void space. Very far beyond this limit, the telescope has revealed objects of greater or less brightness, which, when examined with powerful instruments, are found to consist of millions of minute points, grouped together, and assuming all possible forms, among which the globular manifestly predominates. These are called *clusters* of stars, and are in many instances so large, as to occupy as much, if not more space than that taken up by the Milky Way, and containing, in all probability, as many stars. These magnificent *clusters* are so remote, that the telescope may often grasp, at one view, their vast extent, and innumerable millions of stars. Other bright objects are seen beyond the limits of the stars composing the Milky Way, which assume all possible shapes, and which, in many respects, resemble the clusters; with this difference, that no telescopic power has ever revealed any stars within their limits. These are called *nebulæ*, or faint luminous clouds. Among the nebulæ, some present characteristics which indicate the fact, that in case they could be examined with greater telescopic power, they would be found to be composed of stars too remote to be seen separately, but whose combined light reaches us from their vast distances, and shows them as faint luminous clouds. There are others which exhibit no such characteristics, and which many astronomers believe consist of luminous matter, resembling that composing the tails of comets. These are called *irresolvable nebulæ*. In this class, the most remarkable are the *planetary nebulæ*, so called from the fact that they present disks, very like those of the planets, with a luminous surface of uniform brightness. They resemble the very distant planets of our system, and are, in some instances, only a little less bright.

Among the stars we reckon the following classes, viz.:

Single stars, *double stars*, *multiple stars*, *binary stars*, *periodical or variable stars*, *new stars*, and *nebulous stars*.

Single stars, are those which, to the naked eye, and under telescopic examination, are found to consist of one individual star.

Double stars, are those which, to the naked eye, appear single, but which, under telescopic examination, are found to consist of *two stars*. Sometimes the component stars are equal, at other times they are very unequal, the relative magnitude and distance being different in every set.

Multiple stars, are such as are seen single, by the naked eye, but which the telescope finds composed of *three* or *more components.*

Binary stars, are double stars, in which the components have been found to be united in such a way that they revolve around each other. These are suns revolving about suns, and not a *planet* about a sun.

Variable stars, are those which are found to undergo certain fluctuations in brightness. Sometimes they are found to lose their light, and actually to become invisible. Then they regain their brilliancy, by slow degrees, and reach their original brightness. In some individuals these changes are accomplished in a certain fixed period; in other cases the fluctuations of light are not governed by any known law.

New stars, are those which have suddenly blazed forth in some region of the heavens previously blank or vacant. They generally die away and disappear in the course of one or two years.

Nebulous stars, are such as are surrounded by a faint halo, or luminous haze of nebulous matter.

It will be readily remarked that all these objects, except the single stars, are *telescopic*, and are invisible to the naked eye.

The region in the heavens about four degrees on each side of the ecliptic, or sun's path, is called the *zodiac*, and is remarkable as the region in which the sun, moon, and large planets perform their revolutions among the fixed stars. The constellations, into which the stars in the region of the zodiac were divided, are doubtless among the most ancient in the heavens. In consequence of the apparent annual motion of the sun among the constellations of the zodiac, the stars of these constellations will be successively lost in the superior brilliancy of the sun, and will become invisible while in the immediate vicinity of the sun. This remark is true of all the constellations beyond the limits of the zodiac, and near enough to the sun's track to be above the horizon with the sun, and to be extinguished by his light. As we approach the north pole of the heavens, we find certain groups of stars or constellations which never sink below the horizon, and are consequently visible at all seasons of the year. Others, more remote from the north pole, sink below the horizon, and disappear for only a short time.

As the stars about the south pole of the heavens never rise above the horizon of any place in our northern latitudes, they are never visible to us; and to be seen to advantage, the spectator must travel to southern latitudes.

The Atlas which accompanies this work, contains detailed maps of all the principal constellations, involving the stars down to the sixth magnitude, inclusive, the principal clusters, nebulæ, double stars, &c. The constellation exhibited on any map, is, in general, surrounded by its bounding constellations, so as to show their relative positions. This necessarily occasions the repetition of certain constellations on several maps. But the map intended for use, in the study of each constellation, is referred to in the text describing the constellation.

As each judicious instructor will select his own method of teaching the constellations to his classes, it has been thought best not to arrange this work with reference to one invariable plan, which *must* be followed to render it useful. It is, in general, better to study a constellation, when it occupies a position in the heavens far enough above the horizon to render all its stars visible. This can only occur at a certain season of the year; and as classes will commence the study of astronomy at *any* convenient time, this work is so arranged that the teacher can commence at any constellation which may be favorably situated for examination at the time when his class enters upon the study of the heavens.

In teaching the constellations, it is certainly best to commence with some one in which the principal stars are large and brilliant, and thus easily recognized; such as the stars in Ursa Major, or in Lyra, or in Orion, or in Taurus. Having adopted any point of departure easily recognized, it will not be difficult to refer the surrounding constellations to this point, and gradually to extend the examination until it embraces the whole visible heavens.

The maps present, as nearly as may be, pictures of the heavens, as seen with the naked eye. A faint outline of the figure whose name the constellation bears, is found on the map; not so prominent as to become the striking object, but sufficiently distinct for all useful purposes of reference. These outlines must be retained, as the stars are most readily described, and their places found, by their positions in the constellation. Thus we speak of the bright star Albireo, *in the bill of the Swan;* Aldebaran, *in the eye of the Bull*, &c.; and by the locality thus given, the eye seizes the object on the map at a glance.

The parallels of declination and the hour circles have not been drawn on the map, to prevent confusion; but the degrees of declination are marked on the right and left of the map, and the hours of Right Ascension at the top and bottom. Hence it is easy to determine, from the maps, the A. R. and Dec. of any object.

The double stars are at once recognized, on the maps, by being *double* and *round*, while all other stars are stellated or star-shaped. The nebulæ and clusters are readily distinguished as small faint objects, on the maps.

We commence with the constellations upon and to the east of the prime meridian, and shall trace them in the order in which they appear to reach the meridian, going eastward round the celestial sphere.

As Greek letters so frequently occur in catalogues and maps of the stars, and on the celestial globes, the Greek alphabet is here introduced for the use of those who are unacquainted with it. The capitals are seldom used for designating the stars, but are here given for the sake of regularity.

THE GREEK ALPHABET.

Α	α	Alpha	a
Β	β	Beta	b
Γ	γ	Gamma	g
Δ	δ	Delta	d
Ε	ε	Epsilon	e short
Ζ	ζ	Zeta	z
Η	η	Eta	e long
Θ	ϑ	Theta	th
Ι	ι	Iota	i
Κ	κ	Kappa	k
Λ	λ	Lambda	l
Μ	μ	Mu	m
Ν	ν	Nu	n
Ξ	ξ	Xi	x
Ο	ο	Omicron	o short
Π	π	Pi	p
Ρ	ρ	Rho	r
Σ	ς	Sigma	s
Τ	τ	Tau	t
Υ	υ	Upsilon	u
Φ	φ	Phi	ph
Χ	χ	Chi	ch
Ψ	ψ	Psi	ps
Ω	ω	Omega	o long

To find in what part of the heavens to look for a constellation, at any season of the year and hour of the night, examine the map, and note the mean right ascension of the constellation in question. Then find by the rule (page 14) the meridian passage of the mean right ascension of the constellation on the given day. In case the time at which you seek the constellation is *later* than the time of meridian passage, then the center of the constellation has passed the meridian; on the contrary, should it be earlier, the constellation is east of the meridian, and its angular distance from the meridian will be expressed by the *difference* between the *time of meridian* passage of the center point of the constellation and the *time of examination*.

EXAMPLE.—Where must we look for the constellation Andrómeda, at ten o'clock, P. M., on the 12th of October?

From Map No. 1, the right ascension of the middle point of this constellation is about one hour.

	H.	M.	S.
A. R. of the middle point, =	1	00	00
Tab. No., - - - - - - - - =	10	51	00
Sum =	11	51	00
Time, 10 o'clock, subt., - - -	10	00	00
	1	51	00

The center of the constellation is, therefore, 1h. 51m. east of the meridian; and as the mean declination, shown by the map, is about 40° north, its place may be readily found in the heavens.

It will be well for the student to fix in the heavens some standard of measure, in degrees and in hours. Each hour of right ascension contains fifteen degrees of arc. The distance from the zenith to the horizon is 90°, or one quarter of the whole circumference. If this distance be divided by the eye into six equal parts, each of these parts will be 15°. It should be remembered that hours of A. R. are always measured on the equator, and the hour circles are just 15° apart at the equator, but converge to a point at either pole. Hence the space intercepted on the parallels of declination by two adjacent hour circles, grow smaller the farther the parallel is from the equator, either north or south.

In the notices of the double and binary stars, the *distance* of the components, and the angle formed by a line drawn from the center of the larger component through the center of the smaller one, with the meridian, counting from the north to the east round the circle, are given, with the date or epoch at which the given distance and position were observed. It is by means of measures of the distances and angles of position, that it becomes possible, after many years of observation, to compute the curves which the binary stars describe, in their orbitual motion around their common center of gravity.

In the description of the components, the largest star is called - - - - - A,
The next in size, - - - B;
and if there be more components than two, as is the case with multiple stars, they are named A, B, C, D, &c., in the order of magnitude.

In many instances there is a marked difference in the *color* of the components of double and multiple stars. Whenever this difference is readily recognized, the colors are given in the description of the components.

CHAPTER I.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON MAP NO. I.

ANDROMEDA.
PERSEUS ET CAPUT MEDUSÆ.
TRIANGULUM. THE TRIANGLE.
CASSIOPEIA.

Favorably situated for examination in November, December, and January.

ANDROMEDA.

If we look directly over head at 10 o'clock, on the 10th of November, we shall see the constellation celebrated in fable, by the name of ANDROMEDA. It is represented on the map by the figure of a woman having her arms extended, and chained by her wrists to a rock. It is bounded N. by Cassiopeia, E. by Perseus and the head of Medusa, and S. by the Triangle and the Northern Fish. It is situated between 20° and 50° of N. declination. Its mean right ascension is nearly 15°, or one hour E. of the equinoctial colure.

It consists of 66 visible stars, of which two are of the 2d magnitude, and two of the 3d; most of the rest are small.

The stars directly in the zenith are too small to be seen in the presence of the moon, but the bright star Almaack, marked γ, of the 3d magnitude, in the left knee, may be seen 13° due E., and Merach, marked β, of the 2d magnitude, in the girdle, 7° south of the zenith. This star is then nearly on the meridian, and with two others N. W. of it, form the girdle.

The three stars forming the girdle are of the 2d, 3d, and 4th magnitude, situated in a row, 3° and 4° apart, and are called β, μ, and ν.

If a straight line, connecting γ with β be produced southwesterly, 8° farther, it will reach to δ, a star of the 3d magnitude, in the left breast. This star may be otherwise known by its forming a line. N. and S., with two smaller ones on either side of it; or by its constituting, with two others, a very small triangle, S. of it.

Nearly in a line with γ, β and δ, but curving a little to the N., 7° farther, is a lone star of the 2d magnitude, in the head, called Alpheratz, or α *Andromedæ.* This is the N. E. corner of the great "Square of Pegasus," to be hereafter described.

It will be well to have the position of Alpheratz well fixed in the mind, because it is but one minute W. of the great equinoctial colure, or first meridian of the heavens, and forms nearly a right line with α, in the wing of Pegasus, 14° South of it, and with β, in Cassiopeia, 30° N. of it. If a line, connecting these three stars, be produced, it will terminate in the pole. These three guides, in connection with the North Polar Star, point out to astronomers the position of that great circle in the heavens from which the right ascension of all the heavenly bodies is measured.

Bode has registered 226 stars in Andromeda.

TELESCOPIC OBJECTS.

A DOUBLE STAR.—A. R. = 0 h. 1 m. 43 s. Dec. + 25° 01′ 2″, on the crown of Andromeda's head, in a coarse cluster. A 10, B 11 mag., both reported pale blue. According to Sir William Herschel, this star is surrounded by extensive nebulosity, exceedingly faint and diffused. No outline has yet been given by even the most powerful instruments.
Pos. 120° 0′. Dist. 28″.00. Epoch 1836.81.

22 ANDROMEDÆ.—A. R. = 0 h. 2 m. 2 s. Dec. + 45° 10′ 9″, a fine double star, in the Milky Way, between the left hand of Andromeda and the head of Cassiopeia. A 5, B 8 magnitude.

Stationary. Pos. 85° 5′. Dist. 4″.7. Epoch 1835.

π Andromedæ.—A. R.= 0 h. 28 m. 21 s. Dec. = 32° 50′. A coarse double star, on the left breast of Andromeda. A 4½, B 9 magnitude.
Stationary. Pos. 173° 9′. Dist. 35″.6. Epoch 1832.90.

The Great Nebula in Andromeda.—A. R. = 0 h. 34 m. 5 s. Dec. = + 40° 23′ 6″. Known as far back as 905 A. D., and of course discovered by the naked eye. Besides being the oldest nebula on record, it is the only one fairly visible without the aid of the telescope; yet to see it requires a keen eye, and a pure atmosphere. It was rediscovered by Simon Marius, with the unaided eye, and first examined by him with the telescope, on the 15th Dec., 1612. Owing to the variety in the power of the telescopes used by different observers, in the examination of this object, it has received great diversity of description; some call it round, others oval. Cassini thought it *nearly triangular*.

Sir William Herschel considered this the nearest of all the great nebulæ; on what ground I know not, unless it be its apparent magnitude. He considers its distance to be about two thousand times the distance of Sirius! and if Sirius be as remote as 61 Cygni, then would the light of this object require no less than twenty thousand years, at twelve million miles per minute of time, to reach us. Such periods and distances are not more overwhelming than the magnitude of the object under examination. Great as the above distance may appear, in case we are to regard this *misty light* as an aggregation of millions of distant suns, we must sink it vastly deeper in space, to reconcile the hypothesis with the fact that the stars which compose it have never been revealed by the most powerful instrument.

There is a small attendant, or companion, discovered by Le Jentil in Nov., 1749, which has been partially resolved into stars by Lord Rosse's three feet Reflector.

The drawing was made while under inspection with the twelve inch Refractor of the Cincinnati Observatory.

36 Andromedæ.—A. R. = 0 h. 46 m. 24 s. Dec. + 22° 45′ 7″. A very close double star, in the right elbow of Andromeda. A 6, B 7 magnitude; both of a golden color. The measures indicate a binary character.

Pos. 307° 04′	Dist. 0″.90	Epoch 1830.78	Herschel.
320 47	0 .937	1836.90	Strüve.
322 9	1 ,000	1843.12	Smyth.
330 14	1 .050	1847.70	Mitchel.

μ Andromedæ.—A. R. = 0 h. 47 m. 53 s. Dec. + 37° 37′ 8″. A wide double star in the girdle of Andromeda. A 4, B 16 magnitude.
Pos. 110° 28′. Dist. 49″.19. Epoch 1842 67, Challis.

This object is difficult, in consequence of the minute size of the companion.

55 Andromedæ.—A. R. = 1 h. 43 m. 42 s. Dec. = + 39° 56′ 2″. A delicate double star on the left leg of Andromeda. A 5½, B 16

magnitude. Discovered by Herschel, and marked as "a fine specimen of a nebulous star."

Pos. 350° 0′. Dist. 25″.0. Epoch 1832.95.

γ ANDROMEDÆ.—A. R. = 1 h. 54 m. 06 s. Dec. = + 41° 33′ 6″. A magnificent triple star on the left knee of Andromeda. A $3\frac{1}{2}$, B and C combined make a star of $5\frac{1}{2}$ magnitude. This star was known to be double as far back as 1778. The star was examined and measured as double by all subsequent observers down to Strüve, who in 1842, with the great refractor of the Pulkova observatory, first divided the small star into *two*, making it a triple set. The distance between the close green stars cannot exceed 0″.4, and to see it fairly double requires a most powerful instrument. I obtained many measures of this object, and succeeded in dividing the stars, clearly, showing a difference in the magnitude of the components. The measures of angles of position, agree remarkably well with each other, and give the pos. 110° 00′. Dist. 0″.40. Epoch 1846.6.

It is worthy of remark, that the first examinations of this object, made by myself, were with a *diminished aperture.* These were unsuccessful, and it was only after the full aperture was employed that the stars were clearly divided. This division requires a capital atmosphere, and a smooth clock motion, for its accomplishment.

Pos. A to B, 62° 9′. Dist. 10″.6. Epoch 1837.80.

AN ELONGATED NEBULA.—A. R. = 2 h. 12 m. 35 s. Dec. = + 41° 36′ 1″. On the right foot, a little above a line drawn from β Persei to γ Andromedæ, at about two-thirds the distance from the first star. It very much resembles an annulus seen very obliquely. It was discovered by Miss Caroline Herschel, in August 1783, with a very ordinary reflector, and a power of thirty times. The dark space along the greater axis, was clearly seen by Sir William Herschel, and he regarded the object as an immense ring of myriads of stars, so remote that their individuality was lost under his greatest space-penetrating power.

PERSEUS, ET CAPUT MEDUSÆ.

PERSEUS is represented with a sword in his right hand, the head of Medusa in his left. It is situated directly N. of the Pleiades and the Fly, between Andromeda on the W. and Auriga on the E. Its mean declination is 49° N. It is on the meridian the 24th of December. It contains, including the head of Medusa, 59 stars, one of which is of the 2d magnitude, and four of the 3d. According to Eudosia, it contains, including the head of Medusa, 67 stars.

———— "Perseus next,
Brandishes high in heaven his sword of flame,
And holds triumphant the dire Gorgon's head,
Flashing with fiery snakes! the stars he counts
Are *sixty-seven;* and two of these he boasts,
Nobly refulgent in the *second* rank—
One in his vest, one in Medusa's head."

THE HEAD OF MEDUSA is not a separate constellation, but forms a part of Perseus.

It is represented as the trunkless head of a frightful Gorgon, crowned with coiling snakes, instead of hair, which the victor Perseus holds in his hand.

There are, in all, about a dozen stars in the Head of Medusa; two of the 4th magnitude, and one, varying alternately from the 2d to the 4th magnitude. This remarkable star is called *Algol*, and marked β. It is situated 12° E. of γ, in the knee of Andromeda, and may be known by means of three stars of the 4th magnitude, lying a few degrees S. W. of it, and forming a small triangle.

It is on the meridian the 21st of December; but as it continues above the horizon 18 hours out of 24, it may be seen every evening from September to May. It varies from the 2d to the 4th magnitude in about $3\frac{1}{2}$ hours, and back again in the same time; after which it remains steadily brilliant for $2\frac{3}{4}$ days, when the same changes recur.

The periodical variation of Algol was determined in 1783, by John Goodricke of York (Eng.) to be 2 days, 20 hours, 48 minutes, and 56 seconds.

Dr. Herschel attributes the variable appearance of Algol to spots upon its surface, and thinks it has a motion on its axis similar to that of the *sun*. He also observes, of variable stars generally:—"The rotary motion of stars upon their axes is a capital feature in their resemblance to the sun. It appears to me now, that we cannot refuse to admit such a motion, and that indeed it may be as evidently proved as the diurnal motion of the earth. Dark spots, or large portions of the surface less luminous than the rest, turned alternately in certain directions either towards, or from us, will account for all the phenomena of periodical changes in the luster of the stars, so satisfactorily, that we certainly need not look out for any other cause."

It is said that the famous astronomer Lalande, who died at Paris in 1807, was wont to remain whole nights, in his old age, upon the *Pont Neuf*, to exhibit to the curious the variations in the brilliancy of the star Algol.

Nine degrees E. by N. from Algol, is the bright star *Algenib*, marked α, of the 2d magnitude, in the side of Perseus, which with γ Andromeda, makes a perfect right angle at Algol, with the open part towards Cassiopeia. By means of this strikingly perfect figure, the three stars last mentioned may always be recognized without the possibility of mistaking them. Algenib may otherwise be readily distinguished by its being the brightest and middle one of a number of stars lying four and five degrees apart, in a large semicircular form, curving towards Ursa Major.

Algenib comes to the meridian on the 21st December, 15 minutes after Algol, at which time the latter is almost directly over head. When these two stars are on the meridian, that beautiful cluster, the Pleiades, is about half an hour E. of it; and in short, the most brilliant portion of the starry heavens is then visible in the eastern hemisphere. The glories of the scene are unspeakably magnificent; and the student who fixes his eye upon those lofty mansions of being, cannot fail to covet a knowledge of their order and relations, and to "reverence Him who made the Seven Stars and Orion."

The Milky-Way around Perseus is very vivid, being undoubtedly a rich stratum of fixed stars, presenting the most wonderful and sublime phenomenon of the Creator's power and greatness. Kohler, the astronomer, observed a beautiful nebula near the face of Perseus, besides eight other nebulous clusters in different parts of the constellation.

Bode has registered 196 stars in this constellation.

TELESCOPIC OBJECTS.

76 M. PERSEI.—A. R. = 1 h. 32 m. 16 s. Dec = + 50° 46′ 5″, an oval white nebula, close to the toe of Andromeda, though in the limits of Perseus. Discovered by Mechain. Messier pronounced it a compressed cluster; while Herschel thought it a double irresolvable nebula. With the Northumberland Equatorial, Cambridge, Eng. it has a *spangled appearance.* Prof. Challis says " the resolution is very doubtful."

A MAGNIFICENT CLUSTER.—A. R. = 2 h. 07 m. 58 s. Dec. + 56° 24′ 4″. In the sword handle of Perseus. This is certainly one of the most brilliant and beautiful objects in the heavens; under favorable circumstances, the field of view glows and sparkles with innumerable diamonds, on a ground dark and rich as the blackest velvet.—In the center, five stars are arranged in the form of a bow strongly bent, while a bright 8th mag. star is situated precisely at the point where the thumb and finger would hold the arrow. This cluster is considered by Sir W. Herschel, and with reason, as a protuberant portion of the Milky-Way, or vast stratum of stars of which our own sun is an individual.—With the full aperture of the 12 inch Refractor, all haziness disappears, and the heavens beyond are completely dark and pure, showing that the vision has pierced entirely beyond the limits of space occupied by these stars, and that the interval between them and the nearest group beyond is so great as to hide them absolutely from the view. No drawing can give any idea of the splendor of this object. The one which accompanies this description was taken with care, and gives a correct idea of position and relative magnitude, but not of the sparkling beauty of the stars.

AN ELONGATED NEBULA.—A. R. = 2 h. 30 m. 25 s. Dec. = + 38° 21′ Near the head of Medusa. Discovered by Herschel, 1786. This is probably one of those stupendous rings of stars forming a separate universe, like our own, and seen under great obliquity.

θ. PERSEI.—A. R. = 2 h. 33 m. 8 s. Dec = 48° 32′ 9″. A Triple star on the left shoulder of Perseus. A 4, yellow; B 13, violet; C. 11, gray.—No change in position seems to have occurred since first discovered by Herschel in 1782. Dist. A to B = 15″
A to C = 27″

η PERSEI.—A. R. = 2 h. 39 m. 04 s. Dec. = 55° 13′ 5″. A double or rather multiple star on the head of Perseus. A 5, orange; B 8½, blue. There are many stars in the field. The principal one has three small stars on one side, and one on the other, all nearly in the same straight line, and forming a miniature of Jupiter and his satellites.

No change in position, yet detected.

β PERSEI, *Algol.*—A. R. = 2 h. 57 m. 46 s. Dec. = + 40° 20′ A coarse double star in the head of Medusa, on the shield of Perseus.—A 2 to 4 mag. B. 11. This is the most wonderful among the variable stars. The rapidity and regularity of its changes, the great amount of change in brilliancy, and its double character, mark it as a most extraordinary object.—It diminishes from the 2d to the 4th magnitude in about 3½ hours, retains its diminished splendor about 18 minutes, and in 3½ hours resumes by degrees its former splendor.—Its period is 2d. 20 h. 48 m. 56s.

ε PERSEI.—A. R. = 3 h. 47 m. 08 s. Dec. = + 39° 32′ 4″, a fine double star near the left leg of Perseus. A 3½, B 9. Discovered by Herschel.

Pos. = 8° 32′ Dist. = 8′.00 Ep. 1780.59 Herschel.

A COMPRESSED GROUP.—A. R. = 3 h. 58 m. 11s. Dec. = + 49° 04′ in the left knee of Perseus.—First registered by Herschel 1790.

TRIANGULUM.

The Triangle is supposed to have derived its name from the Egyptian Delta. Formerly there was but one Triangle; a second was added by Hevelius, and is retained on the map.

The Triangles are situated between the head of Aries, on the south, and the knee of Andromeda, on the north. They contain one star of the third, and one of the fourth magnitude. The other stars are small.

Ptolemy reckoned, in this constellation, four stars; Hevelius, nine; Piazzi, twenty-five; and Bode has registered thirty-three stars. Most of them are telescopic.

TELESCOPIC OBJECTS.

A LARGE FAINT NEBULA—A. R. = 1 h. 24 m. 51 s. Dec. + 29° 51′ 03″; between the head of the Northern Fish and the Triangle. Discovered by Messier, 1764; resolved by Herschel, 1783, into minute stars. He locates this object in the 334th order of distances, or regards it as 334 times more remote than stars of the first magnitude.

ε Trianguli.—A. R.=1 h. 53 m. 38 s. Dec.=+32° 30′ 05″. A close double star on the triangle. A $5\frac{1}{2}$, B 15, mag. Discovered by Strüve.

Pos. 110° 0′ Dist. = 5″ Epoch 1835.75 Smyth.

ι Trianguli.—A. R. = 2 h. 3 m. 06 s. Dec. = + 29° 33′. A close double star, under the base of the triangle. A $5\frac{1}{2}$, "topaz yellow," B 7, "green." Discovered by Herschel. Recent measures indicate fixity in the components.

Pos. 77° 50′ Dist. 30″.598 Epoch 1830.97 Struve.

A Close Double Star.—A. R. = 2 h. 19 m. 26 s. Dec. = +29° 12′ 05″. Between the Fly and Triangle. A $6\frac{1}{2}$, B 10. Discovered by Strüve.

Pos. 340° 40′ Dist. 1″.903 Epoch 1832.36 Struve.

CASSIOPEIA.

This constellation is situated 26° N. of Andromeda, and midway between it and the North Polar Star. It may be seen, from our latitude, at all hours of the night, and may be traced out at almost any season of the year. Its mean declination is 60° N. and its right ascension 12°. It is on our meridian the 22d November, but does not sensibly change its position for several days; for it should be remembered that the apparent motion of the stars becomes slower and slower as they approximate the poles.

Cassiopeia is a beautiful constellation, containing 55 stars that are visible to the naked eye; of which one is of the 2d and four are of the 3d magnitude, and so situated as to form, with one or two smaller ones, the figure of an inverted chair.

——— "Wide her stars
Dispersed, nor shine with mutual aid improved;
Nor dazzle, brilliant with contiguous flame:
Their number fifty-five."

Caph, β Cassiopeia, in the garland of the chair, is almost exactly in the equinoctial colure, 30° N. of Alpheratz, α Andromeda, with which, and the Polar Star, it forms a straight line. Caph is therefore on the meridian the 10th of November, and one hour past it on the 24th. It is the westernmost star of the bright cluster. *Schedir*, α Cassiopeia, in the breast, is the uppermost star of the five bright ones, and is 5° S. E. of β : the other three bright ones, forming the chair, are easily distinguished, as they meet the eye at the first glance.

There is an importance attached to the position of β that concerns the mariner and the surveyor. It is used, in connection with observations on the Polar Star, for determining the latitude of places, and for discovering the magnetic variations of the needle.

It is generally supposed that the North Polar Star, so called, is the real immovable pole of the heavens; but this is a mistake. It is *so near* the true pole that it has obtained the appellation of the *North Polar Star;* but it is, in reality, more than a *degree and a half* distant from it, and revolves about the true pole every 24 hours, in a circle whose radius is 1° 31′. It will consequently, in 24 hours, be twice on the meridian, once *above*, and once *below* the pole: and twice at its greatest elongation E. and W.

The polar Star not being exactly in the N. pole of the heavens, but *one degree and* 31 *minutes* on that side of it which is towards Caph, the position of the latter becomes important, as it always shows on which side of the *true* pole the polar star is.

There is another important fact in relation to the position of this star. It is *equidistant* from the pole, and exactly *opposite* another remarkable star in the *square* of the Great Bear, on the other side of the pole. It also serves to mark a spot in the starry heavens, rendered memorable as being the place of a lost star. Two hundred and sixty-six years ago, a bright star shone 5° N. N. E. of Caph, where now is a dark void!

On the 8th of November, 1572, Tycho Brahe and Cornelius Gemma saw a star in the constellation of Cassiopeia, which became all at once, so brilliant, that it surpassed the splendor of the brightest planets, and might be seen even at noonday! Gradually, this great brilliancy diminished, until the 15th of March, 1573, when, without moving from its place, it became utterly extinct.

Its color, during this time, exhibited all the phenomena of a prodigious flame—first it was of a dazzling white, then of a reddish yellow, and lastly of an ashy paleness, in which its light expired. It is impossible, says Mrs. Somerville, to imagine any thing more tremendous than a conflagration that could be visible at such a distance. It was seen for sixteen months.

Some astronomers imagined that it would reäppear again after 150 years; but it has never been discovered since. This phenomenon alarmed all the astronomers of the age, who beheld it; and many of them wrote dissertations concerning it.

Rev. Professor Vince, one of the most learned and pious astronomers of the age, has this remark:—"The disappearance of some stars may be the destruction of that system at the time appointed by the DEITY for the probation of its inhabitants; and the appearance of new stars may be the formation of new systems, for new races of beings then called into existence, to adore the works of their Creator."

Thus, we may conceive the Deity to have been employed from all eternity, and thus he may continue to be employed for endless ages; forming new systems of beings to adore him; and transplanting beings already formed into happier regions, who will continue to rise higher and higher in their enjoyments, and go on to contemplate system after system through the boundless universe.

La Place says :—" As to those stars which suddenly shine forth with a very vivid light, and then immediately disappear, it is extremely probable that great conflagrations, produced by extraordinary causes, take place on their surface. This conjecture, is confirmed by their change of color, which is analogous to that presented to us on the earth by those bodies which are set on fire and then gradually extinguished."

The late eminent Dr. Good also observes that—" Worlds and systems of worlds are not only perpetually creating, but also perpetually disappearing. It is an extraordinary fact, that within the period of the last century, not less than thirteen stars, in different constellations, seem to have totally perished, and ten new ones to have been created. In many instances it is unquestionable, that the stars themselves, the supposed habitation of other kinds or orders of intelligent beings, together with the different planets by which it is probable they were surrounded, have utterly vanished, and the spots which they occupied in the heavens, have become blanks! What has befallen other systems, will assuredly befall our own. Of the time and the manner we know nothing, but the fact is incontrovertible; it is foretold by revelation; it is inscribed in the heavens; it is felt through the earth. Such is the awful and daily text; what then ought to be the comment?"

The great and good Beza, falling in with the superstition of his age, attempted to prove that this was a comet, or the same luminous appearance which conducted the magi, or wise men of the East, into Palestine, at the birth of our Saviour, and that it now appeared to announce his second coming!

About 6° N. W. of Caph; the telescope reveals to us a grand nebula of small stars, apparently compressed into one mass, or single blaze of light, with a great number of loose stars surrounding it.

TELESCOPIC OBJECTS.

A Large and Loose Cluster.—A. R. = 0 h. 18 m. 10 s. Dec. = + 70° 30′ 3″. Registered by Sir Jno. Herschel, and by him regarded as a good test for the light and defining power of a telescope. It is situated between the footstocl and the knee of Cepheus.

A Close Double Star.—A. R. = 0 h. 38 m. 58 s. Dec = 50° 34′ 2.″ Between Andromeda's knee and the head of Cassiopeia. A 7½ B 9 mag.

Pos. 147° 2	Dist. 2″.3	Epoch	1832.87	Smyth.
146 25′	2 .24		1847.60	Mitchel.

The relationship is merely optical.

η Cassiopeia.—A. R.=0 h. 39 m. 27 s. Dec. + 56° 57′ 9″. A binary star in the Cestus of Cassiopeia. A 4 pale white, B 7½ purple, Discovered by Herschel,

1779, when its position was	62° 04	Dist. 11″.27	
1843.19 the measures gave	95 08	9 .1	Smyth.
1847.60	101 20	8 ·59	Mitchel.

Mädler thinks the periodic time of this system will be about 522 years.

μ Cassiopeia.—A. R.=0 h. 57 m. 23 s. Dec. 54° 0′ 8″. A coarse triple star on the right elbow, possessed of an extraordinary proper motion, amounting to 5″.8 in A. R. and 1″.55 in Dec. per annum. In case we locate this star at the distance from our system due to its magnitude, its hourly motion cannot be less than 125,000 miles! a quantity far exceeding the velocity of the swiftest moving planet.

A Loose Cluster.—A. R. = 0 h. 58 m. 19 s. Decl. = + 60° 44′ 0″ below the right hip of Cassiopeia, on the robe, one quarter way on the line joining γ and ϵ. It was discovered by Miss Caroline Herschel, in 1783, and is described by Sir William as "a cluster of pretty compressed stars."

A Small Double Star.—A. R. = 1 h. 9 m. 10 s. Dec. = + 57° 56′ 9″. Between the right knee and elbow of Cassiopeia, A 9. B 10 magnitude.—This object is situated in the center of a brilliant assemblage of small stars discovered by Herschel 1787.

ψ Cassiopeia.—A. R. = 1 h. 14 m. 42 s. Dec. = + 67° 17′ 5″.

A fine triple star close to the lower part of Cassiopeia's throne. A 4½ orange. B 9 blue. C 11 reddish.

Discovered by Strüve.

Pos. A. B.	102° 01′	Dist. 31″.9	Epoch 1836.28	Smyth.
B. C.	252 36	2 .0	1836.28	Smyth.
A. B.	102 37	30 .394	1837.70	Mitchel.
B. C.	253 07	32 856	1837.70	Mitchel.

This object may be found between the north star and δ Cassiopeia, at a little less than one-third of the distance which separates them from the latter star.

An Open Cluster.—A. R. = 1 h. 18 m. 51 s. Dec. = + 61° 27′ 8″. On the lady's leg, half way from ε to γ. Described as "a gathering of small and large stars, with glimpses of star dust of considerable extent."

A Cluster.—A. R. = 1 h. 33 m. 05 s. Dec. = + 61° 01′ 9″. Just below the right knee of Cassiopeia, mid-way between δ and ε Discovered by Herschel, 1787. It is some 2′ or 3′ in diameter, and has an 8½ magnitude star in the center.

55 Cassiopiæ.—A. R. = 2 h. 2 m. 0 s. Dec. + 65° 46′ 2″. A star with two distant companions—located very near the position in the heavens in which the celebrated *new star* of 1572 made its sudden and brilliant appearance. The first sight of this most extraordinary stranger, seems to have been caught by Schiler, of Wittemburgh, as early as the 6th of August, 1572. On the 11th of November, following, the celebrated Tycho Brahé, on returning to his house from his laboratory, was surprised to see some peasants gazing up in the heavens. He soon discovered the object of their curiosity to be a *brilliant star*, which he had never before seen. His finely stocked observatory, gave him an opportunity of observing the stranger with great accuracy. He soon determined that it was located beyond the region of the planets, and even among the fixed stars, as it had no sensible parallax, and never changed its position during the time it remained visible. The brilliancy of this object increased from the time of its discovery, until it surpassed that of Sirius, the brightest of all the fixed stars, and even came to be scarcely less than that of Venus, the most brilliant planet. Having attained its maximum brilliancy, it began to decline by degrees, losing its splendor, until finally, in March 1574, nineteen months after its discovery, it disappeared for ever from the sight. This being the first change in the region of the fixed stars, since the revival of letters in Europe, created a great sensation, and produced a great variety of published accounts. Strange as it may appear, at this day, Tycho was ashamed to publish his observations, to the world, considering it "a disgrace for a nobleman, either to study such subjects, or to publish them to the world."

These new and temporary stars, are among the inscrutable works of God. No intellect, however great, no study, however profound, has yet been able to fathom their mysterious coming and going. Some have suggested the idea that they are moving in excessively elongated orbits, whose principal axes are turned directly towards our own system, and that it is only in their nearest approach to the earth that they become visible. In consequence of the reported appearance of new stars, in the same region, in 915 and 1264, Sir John Herschel has suggested that this may be a periodical star, with a return after intervals of about three hundred years.

It case we estimate the velocity of this star in its orbit, by the diminution of its light, we shall find it moving at so stupendous a rate as to stun the imagination—and we are almost driven from a theory requiring such motion. If we yield to the suggestion of Bessel, that there exist *dark bodies* in space, capable of modifying the movements of the fixed stars, we might account for the sudden appearance of new stars, by their emergence from behind one of these non-luminous bodies. Their disappearance, however, still remains an enigma, and we can only yield and acknowledge that "the heavens declare the glory of God"—whether man can follow or fail.

A Beautiful Triple Star.—A. R. = 2 h. 15 m. 58 s. Dec. + 66° 40′ 7″. Under Cassiopeia's right foot, mid-way between α Persei and γ Cephi. A $4\frac{1}{2}$ pale yellow B 7 lilac. C 9 blue.

Pos. A. B.	274° 2′	Dist. 2″.1	1834.83
A. C.	107 1	Dist. 7 .5	1834.83

No change in position or distance has been remarked since the discovery by Herschel, in 1779.

A Multiple Star.—A. R. = 23 h. 22 m. 40 s. Dec. + 57° 40′. One of the stars was discovered to be close double, by the Rev. W. R. Dawes, 1840.

Pos. 222° Dist. 1″.5

6 Cassiopeiæ.—A. R. = 23 h. 50 m. 55 s. Dec. = + 54° 51′ 8″. A fine double star on the left elbow. A 6. B 8. magnitude. The large star is white, the small one blue, with colors said to be clear and distinct.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. II.

Pisces. The Fishes.

Favorably situated for examination in October, November and December.

THE FISHES.

This constellation is now the first in order, of the

12 constellations of the Zodiac, and is usually represented by two fishes tied a considerable distance apart, at the extremities of a long undulating cord, or ribbon. It occupies a large triangular space in the heavens, and its outline at first is somewhat difficult to trace.

In consequence of the annual precession of the stars, the *constellation* Pisces has now come to occupy the *sign* Aries; each constellation having advanced one whole sign in the order of the Zodiac. The sun enters the sign Pisces, while the earth enters that of Virgo, about the 19th of February, but he does not reach the *constellation* Pisces before the 6th of March. The Fishes, therefore, are now called the "Leaders of the Celestial Hosts."

That loose assemblage of small stars directly south of Merach, α, in the constellation of Andromeda, constitutes the *Northern Fish*, whose mean length is about 16°, and breadth, 7°. Its mean right ascension is 1 h, and its declination 25° N. Consequently, it is on the meridian the 24th of November; and, from its breadth, is more than a week in passing over it. The Northern Fish and its ribbon, beginning at α, Andromedæ, may, by a train of small stars, be traced, in a S. S. easterly direction, for a distance of 33°, until we come to the star El Rischa, α Piscium, of the 2d magnitude, which is situated in the node, or *flexure* of the ribbon. This is the principal star in the constellation, and is situated 2° N. of the equinoctial, and 53 minutes east of the prime meridian.

From α Piscium the ribbon or cord makes a sudden flexure, doubling back across the ecliptic, where we meet with three stars of the 4th magnitude situated in a row 3° and 4° apart, marked on the map ζ, ε, δ. From δ the ribbon runs north and westerly along the Zodiac, and terminates at the tail of the Western Fish. The head of the fish may be recognised by the star β, 4th magnitude, 11° south of α Pegasi.

This part of the ribbon, including the Western Fish at the end of it, has a mean declination of 5° N., and may be seen throughout the month of November, passing the meridian slowly to the W., near where the sun passes it on the 1st of April. Twelve degrees W. of this Fish, there are four small stars situated in the form of the letter Y. The two Fishes, and the cord between them, make two sides of a large triangle, 30° and 40° in length, the open part of which is towards the N. W. When the Northern Fish is on the meridian, the Western is nearly two hours past it. This constellation is bounded N. by Andromeda, W. by Andromeda and Pegasus, S. by the Cascade, and E. by the Whale, the Ram and the Triangles.

When, to enable the pupil to find any star, its direction from another is given, the latter is always understood to be on the meridian.

After a little experience with the maps, even though unaccompanied by directions, the ingenious youth will be able of himself, to devise a great many expedients and facilities for tracing the constellations, or selecting out particular stars.

TELESCOPIC OBJECTS.

179 *P.* XXIII *Piscium.*

A Delicate Double Star.—A. R. = 23 h. 37 m. 49 s. Dec. = — 0° 37′ 4″. Under the preceding Fish, mid-way between Fomalhaux and α Cassiopeia. A 8½. B 15 magnitude.

Discovered by M. Strüve.

Pos. 228° 23′	Dist. 2″.417	Epoch 1832.50	Strüve.
230 00	3 .000	1833.79	Smyth.
227 33	2 .702	1847.65	Mitchel.

These measures afford no evidence of change. Those of Smyth are mere estimations.

34 Piscium.—A. R. = 0 h. 1 m. 53 s. Dec. = + 10° 14′ 6″. A fine double star, near the wing of Pegasus. A 6. B 13½ magnitude.

Discovered by Strüve.

Pos. 160° 08′ Dist. 8″.37 Epoch 1828.73 Strüve.

38 Piscium.—A. R. = 0 h. 9 m. 9 s. Dec. = + 7° 59′ 2″. A double star on the tip of the tail of the preceding Fish. A 7½. B 8 magnitude.

Discovered by Herschel, 1782.

Pos. 244° 57′	Dist. = 4″.00	Epoch 1782.68	
235 54	4 .80	1837.89	Smyth.
235 59	4 .646	1847.65	Mitchel.

These last observations seem to decide the fixity of these stars.

49 Piscium.—A. R. = 0 h. 22 m. 29 s. Dec. = + 15° 09′ 2″. A difficult double star, between the wing of Pegasus and the right hand of Andromeda. A 7. B 13 magnitude.

Discovered by Strüve, and thus measured by him in November 1828.

Pos. 107° 42′ Dist. 13″.26

55 Piscium.—A. R. = 0 h. 31 m. 31 s. Dec. = + 20° 33′ 6″. Between the head and right hand of Andromeda. A 6, orange. B 9, deep blue.

Discovered by Strüve.

Pos. 192° 45′	Dist. 6″.37	Epoch 1830.22	Strüve.
191 52	7 .014	1847.65	Mitchel.

There is no evidence of binary character, and this is doubtless an optical duplicity merely.

65 Piscium.—A. R. = 0 h. 41 m. 18 s. Dec. = + 26° 50′ 3″. A close double star on the right arm of Andromeda. A 6. B 7 magnitude.

Discovered by Sir W. Herschel, who made the following measures.

Pos. 300°.57′	Dist. 4″.00	Epoch 1783.15	
298 30	4 .50	1838.17	Smyth.
297 32		1847.65	Mitchel.

Herschel thought there might be physical connection between the components in this set. If so the period will be very great.

φ Piscium.—A. R. = 1 h. 5 m. 4 s. Dec. = + 23° 44′ 1″. On the ventral fin of the Northern Fish. A 6, B 13 mag.

Discovered by Strüve, and thus measured

Pos. 227° 52′. Dist. 7″.98. Epoch 1832.06.

ζ Piscium.—A. R. = 1 h. 5 m. 21 s. Dec. = + 6° 43′ 7″. A coarse double star on the bend of the band joining the two Fishes. Mädler ranks this among the stars in which there is a probable retrograde motion.

Pos. 67° 23′	Dist. 22″.187	Epoch 1781.88	Herschel.
63° 31′	23″.225	1841.57	Mädler.

A. R. = 1 h. 27 m. 41 s. Dec. = + 6° 49′ 5″. A close double star in the space between the two Fishes and the curve of the Ribbon. A 6½ yellowish, B 8 pale white.

Discovered by Herschel, 1792.

Pos. 20° 00′ Dist. 1″.467 Epoch 1830.23 Strüve.

A. R. = 1 h. 47 m. 38 s. Dec. = 1° 03′ 2″. A close double star at the end of the Ribbon. A 7, B 7½.
Discovered by Strüve, and thus measured by him.
Pos. 64° 42′ Dist. 1″.232 Epoch 1831.12.

α Piscium.—A. R. = 1 h. 53 m. 46 s. Dec. = 1° 59′ 3″. A close double star at the southern extremity of the Ribbon. A 5, pale green. B 6, blue.

Pos. 337° 23′	Dist.	Epoch 1781.79	Herschel.
332° 59′	3″.775	1830.93	Bessel.
331° 48′	3″.733	1831.60	Mädler
330° 03′		1847.65	Mitchel.

Mädler, after a full discussion of all the observations, thinks a retrograde motion is probable. and a period of revolution amounting to about 6000 years. These slowly-revolving objects require close examination; my own measures go to confirm, in some degree, Mädler's opinion.

A Faint Nebula.—A. R. = 23 h. 06 m. 36 s. Dec. = + 3° 39′ 07″. In the eye of the preceding or western Fish. Its length is 4′, and its breadth 1′, according to its discoverer. It is preceded by a fainter nebula. These objects are very difficult in any but the most powerful instruments.
Discovered by Herschel, 1785.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. III.

Aries. The Ram.

Favorably situated for examination in November, December, and January.

THE RAM.

Twenty-two centuries ago, as Hipparchus informs us, this constellation occupied the *first sign* in the ecliptic, commencing at the vernal equinox. But as the constellations gain about 50″ on the equinox, at every revolution of the heavens, they have advanced in the ecliptic nearly 31° beyond it, or more than a whole sign: so that the Fishes now occupy the same place in the Zodiac, that Aries did, in the time of Hipparchus; whence the *constellation* Aries is now in the *sign* Taurus, Taurus in Gemini, and Gemini in Cancer, and so on.

Aries is therefore now the second constellation in the Zodiac. It is situated next east of Pisces, and is midway between the Triangles and the Fly on the N. and the head of Cetus on the S. It contains 66 stars, of which, one is of the 2d, one of the 3d, and several of the 4th magnitudes.

> "First, from the east, the Ram conducts the year;
> Whom Ptolemy with *twice nine* stars adorns,
> Of which two only claim the second rank;
> The rest, when Cynthia fills the sign, are lost."

It is readily distinguished by means of two bright stars in the head, about 4° apart, the brightest being the most north-easterly of the two. The first, which is of the 2d magnitude, situated in the right horn, is called α Arietis, or simply *Arietis;* the other, which is of the 3d magnitude, lying near the left horn, is called Sheratan, β Arietis, and may be known by another star of the 4th magnitude, in the ear, 1½° S. of it, called *Mesarthim*, γ Arietis, which is the *first* star in this constellation.

Arietis and Sheratan, are one instance out of many, where stars of more than ordinary brightness are seen together *in pairs*, as in the Twins, the Little Dog, &c., the brightest star being commonly on the east.

The position of Arietis affords important facilities to nautical science. Difficult to comprehend as it may be, to the unlearned, the skillful navigator who should be lost upon an unknown sea, or in the midst of the Pacific ocean, could, by measuring the distance between Arietis and the Moon, which often passes near it, determine at once not only the spot he was in, but his true course and distance to any known meridian or harbor on the earth.

Lying along the moon's path, there are nine conspicuous stars that are used by nautical men for determining their longitude at sea, thence called *nautical stars*.

These stars are *Arietis*, *Aldebaran*, *Pollux*, *Regulus*, *Spica Virginis*, *Antares*, *Altair*, *Fomalhaut*, and *Markab*.

The true places of these stars, for every day in the year, are given in the Nautical Almanac, a valuable work published annually by the English "Board of Admiralty." to guide mariners in navigating the seas. They are usually published two or three years in advance, for the benefit of long voyages.

That a man, says Sir John Herschel, by merely measuring the moon's apparent distance from a star, with a little portable instrument held in his hand, and applied to his eye, even with so unstable a footing as the deck of a ship, shall say positively within five miles, where he is, on a boundless ocean, cannot but appear to persons ignorant of physical astronomy, an approach to the miraculous. And yet, says he, the alternatives of life and death, wealth and ruin, are daily and hourly staked, with perfect confidence, on these marvelous computations.

Capt. Basil Hall, of the royal navy, relates that he had sailed from San Blas, on the west coast of Mexico, and after a voyage of 8000 miles, occupying eighty-nine days, arrived off Rio Janeiro, having in this interval passed through the Pacific ocean, rounded Cape Horn, and crossed the South Atlantic without making any land or seeing a single sail on the voyage. Arrived within a few days' sail of Rio, he took a set of lunar observations, to ascertain his true position, and the bearing of the harbor, and shaped his course accordingly. "I hove to," says he, "at four in the morning, till the day should break, and then bore up; for although it was hazy, we could see before us a couple of miles or so. About eight o'clock it became so foggy that I did not like to stand in further, and was just bringing the ship to the wind again before sending the people to breakfast, when it suddenly cleared off, and I had the satisfaction of seeing the great Sugar-loaf rock, which stands on one side of the harbor's mouth, so nearly right ahead that we had not to alter our course above a point, in order to hit the entrance of Rio. This was the first land we had seen for three months, after crossing so many seas, and being set backwards and forwards by innumerable currents and foul winds."

Arietis comes to the meridian about twelve minutes after Sheratan, on the 5th December, near where the sun does in midsummer. Arietis, also, is nearly on the same meridian with Almaack, in the foot of Andromeda, 19° N. of it, and culminates only four minutes after it. The other stars in this constellation are quite small, constituting that loose cluster which we see between the Fly on the north, and the head of Cetus on the south.

When Arietis is on the meridian, Andromeda and Cassiopeia are a little past the meridian, nearly over head, and Perseus with the head of Medusa, is as far to the east of it. Taurus and Auriga are two or three hours lower down; Orion appears in the S. E., and the Whale on the meridian, just below Aries, while Pegasus and the Swan are seen half way over in the west.

The manner in which the ancients divided the Zodiac into twelve equal parts, was both simple and ingenious. Having no instrument that would measure time exactly, "They took a vessel, with a small hole in the bottom, and having filled it with water, suffered the same to distil, drop by drop, into another vessel set beneath to receive it, beginning at the moment when some star rose, and continuing till it rose the next following night, when it would have performed one complete revolution in the heavens. The water falling down into the receiver they divided into twelve equal parts: and having twelve other small vessels in readiness, each of them capable of containing one part, they again poured all the water into the upper vessel, and observing the rising of some star in the Zodiac, at the same time suffered the water to drop into one of the small vessels. And as soon as it was full, they removed it, and set an empty one in its place. Just as each vessel was full, they took notice what star of the Zodiac rose at that time, and thus continued the process through the year, until the twelve vessels were filled."

Thus the Zodiac was divided into twelve equal portions, corresponding to the twelve months of the year, commencing at the vernal equinox. Each of these portions served as the visible representative or *sign* of the month it appeared in.

All those stars in the Zodiac which were observed to rise while the first vessel was filling, were constellated and included in the first sign, and called *Aries*, an animal held in great esteem by the shepherds of Chaldea. All those stars in the Zodiac which rose while the second vessel was filling, were constellated and included in the second sign, which for similar reasons, was denominated *Taurus;* and all those stars which were observed to rise while the third vessel was filling, were constellated in the *third* sign, and called Gemini, in allusion to the *twin season* of the flocks.

Thus each sign of 30° in the Zodiac, received a distinctive appellation, according to the fancy or superstition of the inventors; which names have ever since been retained, although the constellations themselves have since left their nominal signs more than 30° behind. The sign Aries, therefore, included all the stars embraced in the first 30° of the Zodiac, and no more. The sign Taurus, in like manner, included all those stars embraced in the next 30° of the Zodiac, or those between 30° and 60°, and so of the rest. Of those who imagine that the twelve constellations of the Zodiac refer to the twelve tribes of Israel, some ascribe Aries to the tribe of Simeon, and others, to Gad.

During the campaigns of the French army in Egypt, General Dessaix discovered among the ruins at Dendera, near the banks of the Nile, the great temple supposed by some to have been dedicated to Isis, the female deity of the Egyptians, who believed that the rising of the Nile was occasioned by the tears which she continually shed for the loss of her brother Osiris, who was murdered by Typhon.

Others suppose this edifice was erected for astronomical purposes, from the circumstance that *two Zodiacs* were discovered drawn upon the ceiling, on opposite sides. On both these Zodiacs the equinoctial points are in Leo, and not in Aries; from which it has been concluded, by those who pertinaciously endeavor to array the arguments of science against the chronology of the Bible and the validity of the Mosaic account, that these Zodiacs were constructed when the sun entered the sign Leo, which must have been 9720 years ago, or 4000 years before the inspired account of the creation. The infidel writers in France and Germany, make it 10,000 years before. But we may "set to our seal," that whatever is true in fact and correct in inference on this subject will be found, in the end, not only consistent with the Mosaic record, but with the common meaning of the expressions it uses.

The discovery of Champollion has put this question for ever at rest; and M. Latronne, a most learned antiquary, has very satisfactorily demonstrated that these Egyptian Zodiacs are merely the horoscopes of distinguished personages, or the precise situation of the heavenly bodies in the Zodiac at their nativity. The idea that such was their purpose and origin, first suggested itself to this gentleman on finding, in the box of a mummy, a similar Zodiac, with such inscriptions and characters as determined it to be the horoscope of the deceased person.

Of all the discoveries of the antiquary among the relics of ancient Greece, the ruins of Palmyra, the gigantic pyramids of Egypt, the temples of their gods, or the sepulchres of their kings, scarcely one so aroused and riveted the curiosity of the learned, as did the discovery of Champollion the younger, which *deciphers the hieroglyphics* of ancient Egypt.

The potency of this invaluable discovery has already been signally manifested in settling a formidable controversy between the champions of infidelity and those who maintain the Bible account of the creation. It has been shown that the constellation *Pisces,* since the days of Hipparchus, has come, by reason of the annual precession, to occupy the same apparent place in the heavens that Aries did two thousand years ago. The Christian astronomer and the infidel are perfectly agreed as to the *fact,* and the *amount* of this yearly gain in the apparent motion of the stars. They both believe, and both can demonstrate, that the fixed stars have gone forward in the Zodiac, about 50" of a degree in every revolution of the heavens since the creation; so that were the world to light upon any authentic inscription or record of past ages, which should give the true position or longitude of any particular star at that time, it would be easy to fix an unquestionable date to such a record. Accordingly, when the famous "Egyptian Zodiacs," which were sculptured on the walls of the temple at Dendera, were brought away *en masse*, and exhibited in the Louvre at Paris, they enkindled a more exciting interest in the thousands who saw them, than ever did the entrance of Napoleon. "Educated men of every order, and those who had the vanity to think themselves such," says the commentator of Champollion, "rushed to behold *the Zodiacs*. These Zodiacs were immediately published and commented upon, with more or less good faith and decorum. Science struck out into systems very bold; and the spirit of infidelity, seizing upon the discovery, flattered itself with the hope of drawing from thence new support. It was unjustifiably taken for granted, that the ruins of Egypt furnished astronomy with monuments, containing observations that exhibited the state of the heavens in the most remote periods. Starting with this assumption, a pretense was made of demonstrating, by means of calculations received as infallible, that the celestial appearances assigned to these monuments extended back from forty to sixty-five centuries; that the Zodiacal system to which they must belong, dated back fifteen thousand years, and must reach far beyond the limits assigned by Moses to the existence of the world." Among those who stood forth more or less bold as the adversaries of revelation, the most prominent was M. Dupuis, the famous author of *L'origine de tous les Cultes*.

The infidelity of Dupuis was spread about by means of pamphlets, and the advocates of the Mosaic account were scandalized "until a new Alexander arose to cut the Gordian knot, which men had vainly sought to untie. This was Champollion the younger, armed with his discovery." The hieroglyphics now speak a language that all can understand, and no one gainsay. "The Egyptian Zodiacs, then," says Latronne, "relate in no respect to astronomy, but to the idle phantasies of judicial astrology, as connected with the destinies of the emperors who made or completed them."

TELESCOPIC OBJECTS.

A Close Double Star.—A. R. = 1 h. 41 m. 19 s. Dec. = + 21° 28′ 7″. On the horn of Aries. A 6, yellow. B 8, blue.

Discovered by Herschel.

Pos.	172° 26′	Dist.	3″.378	Epoch	1823.98	Strüve.
	169 54		2 .400		1836.11	Smyth.

γ Arietis.—A. R. = 1 h. 44 m. 45 s. Dec. = + 18° 30′ 5″. In the lower bend of the Ram's horn. A 4½, B 5. This is the first double star ever detected. Less than one hundred years have elapsed, and now they are numbered by thousands.

Discovered by Dr. Hook 1764.

Mädler thinks motion is probable.

Pos.	183° 55′	Dist.	10″.172	Epoch	1779.63	Herschel.
	179 30		8 .957		1831.79	Strüve.
	178 20		8 .819		1841.78	Mädler.
	175 37		9 .184		1847.65	Mitchel.

If we are to receive these observations as conclusive of periodic revolution, the mighty year of these two suns cannot fall much short of four thousand of our years.

A Round Nebula.—A. R. = 1 h. 50 m. 34 s. Dec. = + 18° 13′ 6″. Following γ on the neck of Aries. It is quite large but faint.

A Quadruple Star.—A. R. = 1 h. 50 m. 43 s. Dec. = + 20° 16′ 7″. Under the ear of Aries. A 6, B 15, C 10, D 9 magnitude. Measures of A and B only are given. The other distances are great.
A to B Pos. = 53° 32′ Dist. 2″.370 Epoch 1832.42 Strüve.

10 Arietis.—A. R. = 1 h. 54 m. 35 s. Dec. = + 25° 09′ 7″. Over the head of the Ram. A 6½, B 8½.
Discovered by Strüve.
Pos. 25° 17′ Dist. 1″.98 Epoch 1833.05 Strüve.

π Arietis.—A. R. = 2 h. 40 m. 22 s. Dec. + 16° 47′ 8″. On the haunch of Aries. A beautiful triple set. A 5, B 8½, C 11 magnitude.
Discovered by Sir W. Herschel, October 1782.

ϵ Arietis.—A. R. = 20 h. 50 m. 04 s. Dec. = + 20° 41′ 08″. A very close double star at the root of the tail of Aries. A 5, B 6½. Discovered by Strüve, and reckoned by him as among his *closest*, and marked "pervicinæ." It was one of the first tests employed after the erection of the Cincinnati Refractor, and so easily separated as to excite the suspicion that the distance between the components has been increasing. This is confirmed by the following measures.

Pos. 188° 50′	Dist. 0″.547	Epoch 1830.16	Strüve.
196 11	0 .764	1841.87	Mädler.

32 Arietis.—A. R. = 2 h. 56 m. 05 s. Dec. = + 24° 37′ 07″. A triple set between the tail of Aries and the Fly. A 6½, B 7, C 15, mag. Discovered by Strüve.

A to B	Pos. 266° 34′ 08″	Dist. 0″.45	Epoch 1841.87	Mädler.
A to C	355 00 00	5 .00	1835.88	Smyth.

A Close Double Star.—A. R. = 3 h. 14 m. 06 s. Dec. = + 20° 23′ 07″. Following the tail of Aries. A 8, B 9, mag.
Discovered by Strüve.
Pos. 93° 42′ Dist. 0″.75 Epoch 1827.16 Strüve.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. IV.

CETUS—THE WHALE.
PART OF ERIDANUS—THE RIVER PO.

Favorably situated for examination in October, November, December, and *January*.

THE WHALE.

As the whale is the chief monster of the deep, and the largest of the aquatic race, so is it the largest constellation in the heavens. It occupies a space of 50° in length, E. and W., with a mean breadth of 20° from N. to S. It is situated below Aries and the Triangles, with a mean declination of 12° S. It is represented as making its way to the east, with its body below, and its head elevated above the equinoctial; and is six weeks in passing the meridian. Its tail comes to the meridian on the 10th of November, and its head leaves it on the 22d of December.

This constellation contains ninety-seven stars; three of the 2d magnitude, nine of the 3d, and several of the 4th. The head of Cetus may be readily distinguished, about 20° S. E. of Aries, by means of five remarkable stars, 4° and 5° apart, and so situated as to form a regular pentagon. The brightest of these is Menkar, α Ceti, of the 2d magnitude, in the nose of the Whale. It occupies the S. E. angle of the figure. It is 3½° N. of the equinoctial, and 15° E. of El Rischa, α Piscium, in the bight of the cord between the Two Fishes. It is directly 37° S. of Algol, and nearly in the same direction from the Fly. It makes an equilateral triangle with Arietis and the Pleiades, being distant from each about 23° S., and may otherwise be known by a star of the 3d magnitude in the mouth, 3° W. of it, called γ, placed in the south middle angle of the pentagon.

ν Is a star of the 4th magnitude, 4° N. W. of γ, and these two constitute the S. W. side of the pentagon in the head of the Whale, and the N. E. side of a similar oblong figure in the neck.

Three degrees S. S. W. of γ, is another star of the 4th magnitude, in the lower jaw, marked δ, constituting the east side of the oblong pentagon ; and 6° S. W. of this, is a noted star in the neck of the Whale, called *Mira*, marked ο, or the "wonderful star of 1596," which forms the S. E. side. This variable star was first noticed as such by Fabricius, on the 13th of August, 1596. It changes from a star of the 2d magnitude so as to become invisible once in 334 days, or about seven times in six years. Herschel makes its period 331 days, 10 hours, and 19 minutes ; while Hevelius assures us that it once disappeared for four years ; so that its true period, perhaps, has not been satisfactorily determined.

The whole number of stars ascertained to be variable, amounts to only 15 ; while those which are suspected to be variable amount to 37.

Mira is 7° S. S. E. of α Piscium, in the bend or knot of the ribbon which connects the Two Fishes. Ten degrees S. of Mira, are four small stars, in the breast and paws, about 3° apart, which form a square, the brightest being on the east. Ten degrees S. W. of Mira, is a star of the 3d magnitude in the heart, called *Baten Kaitos*, ζ Ceti, which makes a scalene triangle with two other stars of the same magnitude 7° and 10° west of it ; also, an equilateral triangle with Mira and the easternmost one in the square.

A great number of geometrical figures may be formed from the stars in this, and in most of the other constellations, merely by reference to the maps; but it is better that the student should exercise his own ingenuity in this way with reference to the stars themselves, for when once he has constructed a group into any letter or figure of his own invention, he never will forget it.

The teacher should therefore require his class to commit to writing the result of their own observations upon the relative position, magnitude and figures of the principal stars in each constellation. One evening's exercise in this way will disclose to the student a surprising multitude of *crosses*, *squares*, *triangles*, *arcs* and *letters*, by which he will be better able to identify and remember them, than by any instructions that could be given.

For example: o and ζ, in the Whale, about 10° apart, make up the S. E. or shorter side of an irregular square, with α in the node of the Ribbon, and another star in the Whale as far to the right of ζ, as α is above o. Again,

There are three stars of equal magnitude, forming a straight line W. of Baten; from which, to the middle star is 10°, thence to the W. one 12½; and 8° or 9° S. of this line, in a triangular direction, is a bright star of the second magnitude in the coil of the tail, called Diphda, or ι.

TELESCOPIC OBJECTS.

12 Ceti.—A. R. = 0 h. 21 m. 53 s. Dec. = — 4° 50′ 06″. A difficult double star, between the Whale's tail and the Southern Fish. A 6, yellow; B 15, blue. Position and distance estimated as follows, in the Bedford Catalogue:
Pos. 180° 56′ Dist. 6″.5 Epoch 1837.89.

A long narrow Nebula.—A. R. = 0 h. 39 m. 45 s. Decl. = — 26° 10′. Near the boundary of the Apparatus Sculptoris.
Discovered by Miss Herschel, in 1783.

42 Ceti.—A. R. = 1 h. 11 m. 38 s. Dec. = — 1° 21′. A close double star, between the whale's back and the band of Pisces.—A 6, B 8 mag. Discovered by Strüve and marked among his "Vicinæ" stars.
Pos. = 334° 30′ Dist. 1″.177 Ep. 1836.91 Strüve.

61 Ceti.—A. R. = 1 h. 55 m. 37 s. Dec. = — 1° 06′ 5″. A double star on the back of the head of Cetus. A 7, B 8½ mag. Discovered by Strüve, who reports the following measures.
Pos. = 250° 00′ Dist. 4″.78. Epoch 1832.36.

o Ceti. Mira.—A. R. = 2 h. 11 m. 16 s. Dec. = — 3° 42′ 3″. A remarkable variable star, with a distant companion, on the middle of the whale's neck. It is the first of these wonderful objects ever discovered, and was noticed by David Fabricius as early as 1596. It becomes as bright as the second magnitude, and then decreases to invisibility. Herschel estimates its period at 331 days 10 hours 19 minutes. Its maximum brilliancy is attained about the first of October at this time. The color of this star is also said to vary with the magnitude.

A Planetary Nebula.—A. R. = 2 h. 19 m. 25 s. Dec. = — 1° 51′ 6″. In the middle of the whale's neck. Discovered by Herschel, 1785.

υ Ceti.—A. R. = 2 h. 27 m. 29 s. Dec. = + 4° 53′ 5″. A double star in the whale's eye. A 4½, yellow, B 15, blue.—This is one of Strüve's "difficiles". He reports the following measures:
Pos. 83° 30′ Dist. 7″.725 Ep. 1831.92.

84 Ceti.—A. R. = 2 h. 33 m. 02 s. Dec. = — 1° 22′ 7″. A difficult object like the preceding, on the whale's under jaw. Strüve, its discoverer furnishes these measures:
Pos. 334° 37′ Dist. 4″.855 Ep. 1831.90.

A Round Nebula.—A. R. = 2 h. 34 m. 30 s. Dec. = — 0° 41′ 02″. On the Whale's lower jaw. Examined by Herschel, and placed in the 910th order of distances; that is, 910 times more remote than the fixed stars of the first magnitude.
Discovered by Messier.

γ Ceti.—A. R. = 2 h. 35 m. 01″. Decl. = + 2° 33′ 05″. A beautiful close double star, in the Whale's mouth. The Bedford Catalogue regards the "fixity" of the components as established; while Mädler thinks an increasing motion certain, with a period of about 569 years. The following measures are reported:

Pos. = 283° 12′	Dist. 2″.835	Epoch 1825.42	Strüve.
287 06	2 .680	1833.36	"
293 37	2 .946	1841.14	Mädler.

An Oval Nebula.—A. R. = 2 h. 38 m. 08 s. Decl. = — 8° 15′ 1″. On the breast of the Whale. "It is pale, though distinct, and brightens at the center."
Discovered by Herschel, 1785.

94 Ceti.—A. R. = 3 h. 04 m. 38 s. Decl. = — 1° 47′ 09″. A difficult double star. in the top of the Whale's tongue. A 5½, B 16, mag.
Discovered by Sir John Herschel.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. V.

TAURUS—THE BULL.
ORION.
PART OF ERIDANUS—THE RIVER PO.

Favorably situated for examination in December, January, February and *March.*

TAURUS.

THE BULL is represented in an attitude of rage, as if about to plunge at Orion, who seems to invite the onset by provocations of assault and defiance. Only the head and shoulders of the animal are to be seen; but these are so distinctly marked that they cannot be mistaken. Taurus is now the *second sign* and *third constellation* of the zodiac; but anterior to the time of Abraham, or more than 4000 years ago, the vernal equinox took place, and the year opened when the sun was in Taurus; and the Bull, for the space of 2000 years, was the prince and leader of the celestial host. The Ram succeeded next, and now the Fishes lead the year. The head of Taurus sets with the sun about the last of May, when the opposite constellation, the Scorpion, is seen to rise in the S. E. It is situated between Perseus and Auriga on the north, Gemini on the east, Orion and Eridanus on the south, and Aries on the west, having a mean declination of 16° north.

It contains 141 visible stars, including two remarkable clusters, called the PLEIADES and HYADES. The first is now on the shoulder, and the latter in the face of the Bull.

The Pleiades, according to fable, were the seven daughters of Atlas and the nymph Pleione, who were turned into stars, with their sisters the Hyades, on account of their amiable virtues and mutual affection.

Thus we everywhere find that the ancients, with all their barbarism and idolatry, entertained the belief that unblemished virtue and a meritorious life would meet their reward in the sky. Thus Virgil represents Magnus Apollo as bending from the sky to address the youth Iulus:—

> "Macte nova virtute puer: sic itur ad astra;
> Diis genite, et geniture Deos."

"Go on, spotless boy, in the paths of virtue; it is the way to the stars; offspring of the gods thyself—so shalt thou become the father of gods."

Our disgust at their superstitions may be in some measure mitigated, by seriously reflecting, that had some of these personages lived in our day, they had been ornaments in the Christian church, and models of social virtue.

The names of the Pleiades are Alcyone, Merope, Maia, Electra, Tayeta, Sterope and Celeno. Merope was the only one who married a mortal, and on that account her star is dim among her sisters.

Although but six of these are visible to the naked eye, yet Dr. Hook informs us that, with a twelve feet telescope, he saw 78 stars; and Rheita affirms that he counted 200 stars in this small cluster.

The most ancient authors, such as Homer, Attalus, and Geminus, counted only *six* Pleiades; but Simonides, Varro, Pliny, Aratus, Hipparchus, and Ptolemy, reckon them seven in number; and it was asserted, that the seventh had been seen before the burning of Troy; but this difference might arise from the difference in distinguishing them with the naked eye.

The Pleiades are so called from the Greek word, πλειν, *pleein*, to *sail;* because, at this season of the year, they were considered "the star of the ocean" to the benighted mariner. *Alcyone*, of the 3d magnitude, being the brightest star in this cluster, is sometimes called the *light of the Pleiades*. The other five are principally of the 4th and 5th magnitudes.

The Pleiades, or as they are more familiarly termed, the *seven stars*, come to the meridian 10 minutes before 9 o'clock, on the evening of the 1st of January, and may serve, in place of the sun, to indicate the time, and as a guide to the surrounding stars.

According to Hesiod, who wrote about 900 years before the birth of our Saviour, the heliacal rising of the Pleiades took place on the 11th of May, about the time of harvest.

> " When, Atlas-born, the Pleiad stars arise
> Before the sun above the dawning skies,
> 'Tis time to reap; and when they sink below
> The morn-illumin'd west, 'tis time to sow."

Thus, in all ages, have the stars been observed by the husbandman, for " signs and for seasons."

Pliny says that Thales, the Miletan astronomer, determined the cosmical setting of the Pleiades to be 25 days after the autumnal equinox. This would make a difference between the setting at that time and the present, of 35 days, and as a day answers to about 59′ of the ecliptic, these days will make 34° 25′. This, divided by the annual precession (50¼′), will give 2465 years since the time of Thales. Thus does astronomy become the parent of chronology.

If it be borne in mind that the stars uniformly rise, come to the meridian, and set about four minutes earlier every succeeding night, it will be very easy to determine at what time the seven stars pass the meridian on any night subsequent or antecedent to the 1st of January. For example: at what time will the seven stars culminate on the 5th of January? Multiply the five days by four, and take the result from the time they culminate on the 1st, and it will give thirty minutes after eight o'clock in the evening.

The Pleiades are also sometimes called *Vergiliæ*, or the " Virgins of spring;" because the sun enters this cluster in the "season of blossoms," about the 18th of May. He who made them alludes to this circumstance when he demands of Job: "Canst thou bind the sweet influences of the Pleiades," &c.—[Job xxxviii, 31.]

The Syrian name of the Pleiades is *Succoth*, or *Succoth-Benoth*, derived from a Chaldaic word, which signifies "to speculate, to observe," and the "Men of Succoth" (2 Kings xvii, 30), have been thence considered observers of the stars.

The *Hyades* are situated 11° S. E. of the Pleiades, in the face of the Bull, and may be readily distinguished by means of five stars so placed as to form the letter V. The most brilliant star is on the left, in the top of the letter, and called *Aldebaran*, α Tauri, from which the moon's distance is computed.

> "A star of the first magnitude illumes
> His radiant head; and of the second rank,
> Another beams not far remote."

Aldebaran is of Arabic origin, and takes its name from two words which signify, "He went before, or led the way"—alluding to that period in the history of astronomy when this star led up the starry host from the vernal equinox. It comes to the meridian at nine o'clock on the 10th of January, or 48½ minutes after Alcyone, η Tauri, on the 1st. When Aries is about 27° high, Aldebaran is just rising in the east. So MANILIUS:—

> "Thus when the *Ram* hath doubled ten degrees,
> And join'd seven more, then rise the Hyades."

A line 15½° E. N. E. of Aldebaran will point out a bright star of the 2d magnitude in the extremity of the northern horn, marked β or El Nath; (this star is also in the foot of Auriga, and is common to both constellations.) From β in the northern horn, to ζ in the tip of the southern horn, it is 8°, in a southerly direction. This star forms a right angle with α and β. β and ζ, both, in the button of the horns, are in a line nearly north and south, 8° apart, with the brightest on the north. That very bright star 17½° N. of β, is *Capella* α, in the constellation *Auriga*.

This map contains the most brilliant, and on all accounts, the most interesting portions of the heavens. According to the investigations of Strüve, this region is nearer to our sun and system than any other portion of the celestial sphere, as will be more fully developed hereafter. Besides this, Alcyone is regarded as the great center of the millions of stars clustered together and forming the Milky Way.

This region, on account of its splendor, and the remarkable configurations of its stars, forms an admirable point in beginning the study of the heavens.

TELESCOPIC OBJECTS.

7 TAURI.—A. R. = 3 h. 24 m. 58 s. Dec. = + 23° 55′ 4″. A triple star on the back of Taurus. A 6, B 6½, C 11 magnitude.

Discovered by Strüve, and two of the components are among his "vicinessemæ," or close stars. From his measures, compared with Mädler's, a retrograde movement in A and B seems to be certain.

	Pos.	Dist.	Epoch	
A to B	271° 00′	= 0″.63	1827.16	Strüve.
	264 35	0 .55	1841.80	Mädler.
$\frac{A + B}{2}$ to C	63° 36	22″.25	1827.16	Strüve.
	60 18	22 .50	1841.80	Mädler.

The period of A about B, is probably about 580 or 590 years.

30 TAURI.—A. R. = 3 h. 39 m. 30 s. Dec. = + 16° 38′ 8″. A delicate double star on the left shoulder-blade of Taurus. A 6, "pale emerald." B 10, "purple."

Discovered by Herschel.

Pos. 58° 46′ Dist. 9″.867 Epoch 1824.98 Strüve.

A DOUBLE STAR.—A. R. = 3 h. 51 m. 27 s. Dec. = 22° 44′ 7″. In the neck of Taurus, between the Pleiades and Hyades. A 7½, B 8 magnitude. A distant companion of the 12 magnitude.

Discovered by Strüve.

Pos. 127° 41′ Dist. 7″.208 Epoch 1823.98 South.

80 TAURI.—A. R. = 4 h. 21 m. 01 s. Dec. = + 15° 17′. A close double star on the Bull's face, 1½° south west of Aldebaran. A 6, B 8½.

Pos. 12° 55′ Dist. 1″.74 Epoch 1831.18 Strüve.

A CLOSE DOUBLE STAR.—A. R. = 5 h. 7 m. 23 s. Dec. + 18° 15′ 3″. On the southern horn of Taurus. A 8, B 8½.

Discovered by Strüve.

Pos. 171° 13′ Dist. 2″.327 Epoch 1830.53 Strüve.

A DOUBLE STAR.—A. R. = 5 h. 8 m. 03 s. Dec. = + 19° 57′ 2″. In the middle of the southern horn of Taurus. A 8, B 11 magnitude.

Discovered by Strüve.

Pos. 147° 33′ Dist. 10″.547 Epoch 1828.19 Strüve.

118 TAURI.—A. R. = 5 h. 19 m. 25 s. Dec. = + 25° 00′ 8″. Between the tips of the Bull's horns. A 7, B 7½.

Pos. 196° 46′ Dist. 4″.89 Epoch 1829.63 Strüve.

A Large Nebula.—A. R. = 5 h. 24 m. 51 s. Decl. = + 21° 54′ 02″. One degree N. W. of ζ Tauri, on the tip of the Bull's southern horn. Discovered by Messier, 1758, and is No. 1 of his great catalogue. It was accidentally picked up while observing the comet of that year, and induced Messier to commence a search for such objects. It is resolved with difficulty by the best instruments, and Herschel reckons its profundity of the 980th order—that is, 980 times more remote than stars of the first magnitude.

η Tauri.—A. R. = 3 h. 37 m. 59 s. Decl. = + 23° 36′ 3″. Alcyone, the principal star in the Pleiades, a small cluster visible to the eye in the neck of Taurus. This little group has ever been remarkable, but recently a tenfold interest has been given to it by the announcement of Dr. Mädler of Dorpat, Russia, that its chief star, Alcyone, is the *central sun* of our *astral system*. It is absolutely certain that the law of gravitation extends to the fixed stars, as is abundantly shown by the orbitual revolution of the double stars, whose periods and places have been computed and predicted by the application of this law.

This being certain, in the mighty group of millions of stars with which our own sun is associated, there *must* be a *center of gravity;* and it then remains to determine whether this point is filled by a ponderous globe, of vast dimensions, and bearing the same relation in point of magnitude to the millions of suns by which it is surrounded, as our sun does to the planets, satellites, and comets by which it is encircled. Analogy, in the solar system, taught the existence of such a ponderous mass, but this analogy was broken in the revolving stars; in which it often occurs that the components are nearly equal in magnitude, moving round a common center of gravity.

Again, in examining the heavens, such a mighty preponderating body would be detected by the swifter proper motion of the stars in its vicinity. After a laborious search, Mädler reached the conclusion that no such vast globe existed, and that the center of gravity, probably vacant, could only be found by a severe examination of the proper motions of the fixed stars. By a beautiful train of reasoning and closely conducted research, he finally reached the conclusion that *Alcyone*, in the Pleiades, *now* holds the high rank of *central sun;* but that, in the course of ages, by the perpetual changes constantly going on among the components of our *astral system*, this rank may pass to some other star. He computes roughly the distance of Alcyone, and reckons it to be so great, that light, flying with a velocity of twelve millions of miles a minute, cannot reach us from that star in less than 537 years. He further computes roughly, that our sun revolves about Alcyone in a period of 18,200,000, in an orbit inclined to the ecliptic under an angle of 84° 00′. Should this wonderful theory be confirmed, the proper motions of the fixed stars assume a new and increased interest.—(See Mädler's Paper, "Central Sun"—Mitchel's Sidereal Messenger, Nos. 4 and 5, Vol. I.)

A Nebulous Star.—A. R. = 3 h. 59 m. 06 s. Decl. + 30° 20 05″. Over the neck of Taurus. This object was discovered by the elder Herschel, and was the final link in that long chain of observation which led to the adoption of the "nebular theory." The star is perfectly in the center of the nebulous atmosphere which surrounds it, and Herschel argues the nebulosity of this seeming atmosphere from the fact that, in case each shining point is a star, what must be the magnitude of the central orb, which exceeds them all in the enormous ratio of millions to one. These nebulous stars are certainly most wonderful objects, and deserve the most rigid scrutiny.

χ TAURI.—A. R. = 4 h. 12 m. 51 s. Decl. = + 25° 14′ 07″. A double star at the back of the Bull's ear. A 6, B 8, mag.
Pos. 25° 00′ Dist. 19″.3 Epoch 1831.91 Smyth.

ORION.

WHOEVER looks up to this constellation and learns its name, will never forget it. It is too beautifully splendid to need a description. When it is on the meridian, there is then above the horizon the most magnificent view of the celestial bodies that the starry firmament affords; and it is visible to all the habitable world, because the equinoctial passes through the middle of the constellation. It is represented on celestial maps by the figure of a man in the attitude of assaulting a Bull, with a sword in his belt, a huge club in his right hand, and the skin of a lion in his left, to serve for a shield.

Manilius, a Latin poet, who composed five books on astronomy, a short time before the birth of our Saviour, thus describes its appearance:

"First next the Twins, see great *Orion* rise,
His arms extended stretch o'er half the skies;
His stride as large, and with a steady pace
He marches on, and measures a vast space;
On each broad shoulder a bright star display'd,
And three obliquely grace his hanging blade.
In his vast head, immers'd in boundless spheres,
Three stars, less bright, but yet as great, he bears,
But farther off removed, their splendor's lost;
Thus grac'd and arm'd, he leads the starry host."

The center of the constellation is midway between the poles of the heavens and directly over the equator. It is also about 8° W. of the solstitial colure, and comes to the meridian about the 23d of January. The whole number of visible stars in this constellation is seventy-eight; of which two are of the 1st magnitude, four of the 2d, three of the 3d, and fifteen of the 4th.

Those four brilliant stars in the form of a long square or parallelogram, intersected in the middle by the "Three Stars," or "Ell and Yard," about 25° S. of the Bull's horns, form the outline of Orion. The two upper stars in the parallelogram are about 15° N. of the two lower ones; and, being placed on each shoulder, may be called the epaulets of Orion. The brightest of the two lower ones is in the left foot, on the W., and the other, which is the least brilliant of the four, in the right knee. To be more particular: Bellatrix, γ Orionis, is a star of the 2d magnitude on the W. shoulder; Betelguese, α Orionis, is a star of the 1st magnitude, $7\frac{1}{2}$° E. of Bellatrix, on the E. shoulder. It is brighter than Bellatrix, and lies a little farther towards the north; and comes to the meridian thirty minutes after it, on the 21st of January. These two form the upper end of the parallelogram.

Rigel, β Orionis, is a splendid star of the 1st magnitude, in the left foot, on the W. and 15° S. of Bellatrix. *Saiph*, is a star of the 3d magnitude, in the end of the sword scabbard, $8\frac{1}{2}$° E. of Rigel. These two form the lower end of the parallelogram.

> ————"First in rank
> The martial star upon his shoulder flames:
> A rival star illuminates his foot;
> And on his girdle beams a luminary
> Which, in vicinity of other stars,
> Might claim the proudest honors."

There is a little triangle of three small stars in the head of Orion, which forms a larger triangle with the two in his shoulders. In the middle of the parallelogram are three stars of the 2d magnitude, in the belt of Orion, that form a straight line about 3° in length from N. W. to S. E. They are usually distinguished by the name of the *Three Stars*, because there are no other stars in the heavens that exactly resemble them in position and brightness. They are sometimes denominated the *Three Kings*, because they point out the Hyades and Pleiades on one side, and Sirius, or the Dog-star on the other. In Job they are called the *Bands of Orion;* while the ancient husbandmen called them *Jacob's rod*, and some times the *Rake*. The University of Leipsic, in 1807, gave them the name of *Napoleon*. But the more common appellation for them, including those in the sword, is the *Ell and Yard*. They derive the *latter* name from the circumstance that the line which unites the "three stars" in the belt measures just 3° in length, and is divided by the central star into two equal parts, like a yard-stick; thus serving as a graduated standard for measuring the distances of stars from each other. When therefore any star is described as being so many degrees from another, in order to determine the distance, it is recommended to apply this rule.

It is necessary that the scholar should task his ingenuity only a few evenings in applying such a standard to the stars, before he will learn to judge of their relative distances with an accuracy that will seldom vary a degree from the truth.

The northernmost star in the belt, called *Mintika*, δ, is less than ½° S. of the equinoctial, and when on the meridian, is almost exactly over the equator. It is on the meridian, the 24th of January.

The "three stars" are situated about 8° W. of the solstitial colure, and uniformly pass the meridian one hour and fifty minutes after the seven stars.

There is a row of stars of the 4th and 5th magnitudes, S. of the belt, running down obliquely towards Saiph, which forms the sword. This row is also called the *Ell*, because it is once and a quarter the length of the *Yard* or belt.

A very little way below Thabit, ϑ Orionis, in the sword, there is a nebulous appearance, the most remarkable one in the heavens. With a good telescope an apparent opening is discovered, through which, as through a window, we seem to get a glimpse of other heavens, and brighter regions beyond.

As the telescope extends our knowledge of the stars and greatly increases their visible number, we behold hundreds and thousands, which, but for this almost divine improvement of our vision, had forever remained, unseen by us, in an unfathomable void.

A star in Orion's sword, which appears single to the unassisted vision, is multiplied into six by the telescope; and another into twelve. Galileo found eighty in the belt, twenty-one in a nebulous star in the head, and about five hundred in another part of Orion, within the compass of one or two degrees. Dr. Hook saw seventy-eight stars in the Pleiades, and Rheita with a better telescope, saw about two hundred in the same cluster and more than two thousand in Orion.

About 9° W. of Bellatrix, γ, are eight stars, chiefly of the 4th magnitude, in a curved line running N. and S. with the concavity towards Orion; these point out the skin of the lion in his left hand. Of Orion, on the whole, we may remark with Eudosia:

"He who admires not, to the stars is blind."

As the constellation Orion, which rises at noon about the 9th day of March, and sets at noon about the 21st of June, is generally supposed to be accompanied, at its rising, with great rains and storms, it became extremely terrible to mariners, in the early adventures of navigation. Virgil, Ovid, and Horace, with some of the Greek poets, make mention of this.

Thus Eneas accounts for the storm which cast him on the African coast on his way to Italy:—

"To that blest shore we steer'd our destined way,
When sudden, dire *Orion* rous'd the sea:
All charg'd with tempests rose the baleful star,
And on our navy pour'd his wat'ry war."

To induce him to delay his departure, Dido's sister advises her to

"Tell him, that, charg'd with deluges of rain,
Orion rages on the wintry main."

The name of this constellation is mentioned in the books of Job and Amos, and in Homer. The inspired prophet, penetrated like the psalmist of Israel, with the omniscience and power displayed in the celestial glories, utters this sublime injunction: "Seek Him that maketh the seven stars and Orion, and turneth the shadow of death into morning." Job also, with profound veneration, adores His awful majesty who "commandeth the sun and sealeth up the stars; who alone spreadeth out the heavens, and maketh Arcturus, Orion, and Pleiades, and the chambers of the south:" And in another place, the Almighty demands of him—"Knowest thou the ordinances of heaven? Canst thou bind the sweet influences of the Pleiades, or loose the bands of Orion; canst thou bring forth Mazzaroth in his season, or canst thou guide Arcturus with his sons?"

Calmet supposes that *Mazzaroth* is here put for the whole order of celestial bodies in the Zodiac, which by their appointed revolutions, produce the various seasons of the year, and the regular succession of day and night. *Arcturus* is the name of the principal star in Bootes, and is here put for the constellation itself. The expression, *his sons*, doubtless refers to Asterion and Chara, the two greyhounds, with which he seems to be pursuing the great bear around the North pole.

TELESCOPIC OBJECTS.

258 P. IV. Orionis.—A. R. = 4 h. 49 m. 48 s. Dec. = + 1° 25′ 04″. A double star preceding Orion's right knee. A 8½, B 9, mag. Discovered by Herschel.

Pos. 174° 51′	Dist. 2″.00	Epoch 1782.85	Herschel.
179 54	2 .64	1832.09	Strüve.

ζ Orionis.—A. R. = 5 h. 04 m. 55 s. Dec. = + 2° 39′ 09″. A double star between the right arm and thigh of Orion. A 5, B 8½, the first orange, the second blue.

Pos. 63° 28′ Dist. 7″.05 Epoch 1832.05 Strüve.

β Orionis.—A. R. = 5 h. 6 m. 51 s. Dec. = — 8° 23′ 05″. *Rigel*, a double star in the right foot of Orion. A 1, "pale yellow," B 9, "sapphire blue." A third star has been recently added by artificial occultation, at the Cincinnati Observatory. It is of the 20th magnitude, and invisible without hiding the principal stars.

The relative positions of the stars remain unchanged since their discovery, in 1781.

Discovered by Herschel.

Pos. 199° 46′ Dist. 9″.14 Epoch 1831.53 Strüve.

84 P. V. Orionis.—A. R. = 5 h. 16 m. 53 s. Dec. = + 1° 46′ 4″. A close double star in Orion's right side. A 8, B 10. The components are fixed.

Discovered by Herschel.

Pos. 323° 13′ Dist. 2″.61 Epoch 1831.81.

32 Orionis.—A. R. = 5 h. 22 m. 13 s. Dec. = + 5° 49′ 03″. A close double star on the right shoulder of Orion. A 5, B 7, mag. A com-

parison of late measures with those of Herschel in 1780, indicates a slow retrograde motion, amounting to some 10° or 12° in half a century.

Pos. 203° 45′ Dist. 1″.04 Epoch 1830.96 Strüve.

33 Orionis.—A. R. = 5 h. 22 m. 51 s. Dec. = + 3° 09′ 9″. A close double star on the right shoulder. A 6, B 8, mag.

Pos. 25° 35′ Dist. 1″.87 Epoch 1831.22 Strüve.

λ Orionis.—A. R. = 5 h. 26 m. 19 s. Dec. = + 9° 49′ 03″. A double star in the ear of Orion. A 4, "pale white," B 6, violet. No change has been detected.

Discovered by Herschel, 1779.

Pos. 40° 32′ Dist. 4″.24 Epoch 1830.21 Strüve.

θ Orionis.—A. R. = 5 h. 27 m. 25 s. Dec.—5° 30′. A sextuple star in the great nebula in the sword scabbard of Orion. A 6, B 7, C 7½, D 8, E 15, F 16, mag. For more than fifty years this object was regarded as only *quadruple.* After the mounting of the "Dorpat refractor," Strüve added a *fifth* star to the four already known; and a few years since a *sixth* was discovered by Sir James South.

It is not certain that any change has yet been detected among the components of this remarkable group.

	Pos.	Dist.	Epoch	
A B,	311° 14′	12″.983	1832.53	Strüve.
A C,	60 07	13 .467	1832.53	"
A D,	342 10	16 .780	1832.53	"
B E,	355 42	3 .860	1832.53	"

The Great Nebula in Orion.—A. R. = 5 h. 27 m. 25 s. Dec. = — 5° 30′. This stupendous object is situated in the middle of the scabbard of Orion's sword. Discovered by Huygens, 1656. It has been an object of the greatest interest, to all astronomers, in consequence of its brilliancy and extraordinary magnitude. Sir William Herschel repeatedly examined it with scrutiny with his forty feet refractor, but detected nothing like resolvability. Most accurate drawings were made by his son, without any suspicion that it was composed of a mass of stars. As Sir John Herschel remarked, the greater the power employed the more mysterious did the object appear. Dr. J. Lamont, of Munich, has examined this nebula with great attention, and many years since affirmed that with the twelve inch refractor of the Munich Observatory, he caught glimpses of multitudes of *point-like stars,* crowding and producing the brighter parts of the nebula; yet to this announcement little heed seems to have been given. On mounting the giant reflector of Lord Rosse, it was a matter of deep interest to learn the appearance of this nebula under the scrutiny of this magnificent instrument. More than one astronomer made the journey to the castle of Lord Rosse, to inspect this wonderful object. For a long time it resisted the full power of the greatest of all optical instruments, until at length Lord Rosse makes the following announcement:

"*Castle Parsontown, March* 19, 1846.

"In accordance with my promise of communicating to you the result of our examination of Orion, I think I can safely say there can be but little, if any doubt, as to the resolvability of the nebula. Since you left us, there was not a single night, when, in absence of the moon, the air was free enough to admit the use of more than half the magnifying power the speculum bears; still, we could plainly see, that all about the trapezium is a mass of stars; the rest of the nebula abounding in stars, and exhibiting the characteristics of resolvability strongly marked.

"ROSSE."

This announcement has been made the basis of an argument, by Dr. Nichol, to overthrow the nebular theory of the formation of the universe; a theory which had derived much of its popularity from the powerful argument in its behalf made by the same gentleman, a short time before, in his "Architecture of the Heavens." If Lord Rosse is quite sure of the resolution of the nebula, it but confirms the previous declaration of Dr. Lamont, and the nebular theory loses but little of its former strength by the removal of a prop already much shaken by the Munich Astronomer. Resolved or unresolved, this is certainly, under every aspect, one of the most sublime objects revealed by telescopic agency—so vast that the mind fails, utterly, to grasp its mighty outlines. As a starry system, it is so distant that the light which leaves it, to journey to our eyes, spends no less than 30,000 years in sweeping over the stupendous interval. As a nebula, it contains materials sufficient for the production of millions of suns and systems. View it as we may, its vastness, its magnificence, must exalt our ideas of the omnipotence of the Great Architect of the Heavens. Under the full power of the Cincinnati refractor, the deep contrast between the brilliancy of the stars and nebulosity. and the jet black heavens on which they are seen, is one of the most beautiful sights in the heavens. Whether this *blackness* be the effect of mere contrast, or an intrinsic darkness, occasioned by the absence of all light, it is difficult to determine. This is not a solitary instance of the phenomenon in question. I have observed the same in several other instances—but in no case have I remarked such intense blackness in the heavens, as about this nebula.

σ ORIONIS.—A. R. = 5 h. 30 m. 43 s. Dec. = — 2° 41′ 8″. A multiple star just below the belt of Orion, an excellent object for testing the light of telescopes. There are no less than *ten* stars counted as the components of this one. A 4, a 11, B 8, C 7, D 8½, E 9, F 8, magnitudes.

34 HERSCHEL, ORIONIS.—A. R. = 5 h, 33 m. 21 s. Dec. = + 9° 00′ 2″. A planetary nebula on Orion's neck.

Discovered by Herschel, and described by his son as "a small pale, but distinct nebula, with a faint disc, rather oval, and perhaps a little mottled."

78 MESSIER, ORIONIS.—A. R. = 5 h. 38 m. 33 s. Dec. = + 0° 00′ 7″. "Two stars in a wispy nebula, just above Orion's hip." This is a remarkable object.

Discovered by Messier in 1780.

52 Orionis.—A. R. = 5 h. 39 m. 24 s. Dec. = + 6° 23′ 6″. A close double star in Orion's left shoulder. A 6, B 6½ magnitude. The position has never changed.
Pos. 200° 01 Dist. 1″.75 Epoch 1831.23 Strüve.

ERIDANUS.

The River Po.—This constellation meanders over a large and very irregular space in the heavens. It is not easy, nor scarcely desirable, to trace out all its windings among the stars. Its entire length is not less than 130°; which, for the sake of a more easy reference, astronomers divide into two sections, the northern and the southern. That part of it which lies between Orion and the Whale, including the great bend about his paws, is distinguished by the name of the *Northern stream;* the remainder of it is called the *Southern stream.*

The Northern stream commences near Rigel (Map No. V), in the foot of Orion, and flows out westerly, in a serpentine course nearly 40°, to the Whale (Map No. IV), where it suddenly makes a complete circuit and returns back nearly the same distance towards its source, but bending gradually down towards the south, when it again makes a similar circuit to the S. W. and finally disappears below the horizon.

West of β Orionis (Map No V) there are five or six stars of the 3d and 4th magnitudes, arching up in a semicircular form, and marking the *first* bend of the northern stream. About 8° below these, or 19° W. of β, is a bright star of the 2d magnitude, in the *second* bend of the northern stream, marked γ. This star culminates thirteen minutes after the Pleiades, and one hour and a quarter before β. Passing γ, and a smaller star west of it, there are four stars nearly in a row, which bring us to the breast of Cetus. 8° N. of γ, is a small star named *Kied*, which is thought by some to be considerably nearer the earth than Sirius.

Theemim, in the southern stream, is a star of the 3d magnitude, about 17° S. W. of the square in Lepus, and may be known by means of a smaller star, 1° above it. *Achernar* is a brilliant star of the 1st magnitude, in the extremity of the southern stream; but having 58° of S. declination, can never be seen in this latitude.

The whole number of stars in this constellation is eighty-four; of which, one is of the 1st magnitude, one of the 2d, and eleven are of the 3d. Many of these cannot be pointed out by verbal description; they must be traced from the map.

TELESCOPIC OBJECTS.

98. P, III, Eridani.—A. R. = 3 h. 28 m. 35 s. Dec. = + 0° 03′ 7″. A delicate double star, in the line joining α Ceti and β Orionis, at one-third their distance. A 6½, yellow; B 9, pale blue.

Discovered by Herschel.

Pos. 225° 12′ Dist. 5″.812 Epoch 1824.02 Strüve.

This object is between the Bull's chest and the northern branch of the River.

107 Herschel I, Eridani.—A. R. = 3 h. 33 m. 02 s. Dec. = — 19° 04′ 8″. A white nebula between the two northern reaches of the River.

Discovered by Herschel, and described as "pale but distinct, round and bright in the center."

32 Eridani.—A. R. = 3 h. 46 m. 16 s. Dec. = — 3° 25′ 9″. A double star between the chest of Taurus and the River. A 5, yellow; B 7, sea green.

Discovered by Herschel.

Pos. 349° 45′ Dist. 6″.75 Epoch 1825.00 Strüve.

39 Eridani.—A. R. = 4 h. 06 m. 48 s. Dec. — 10° 39′ 4″. A double star in the north, following bend of the River. A 5, "full yellow;" B 11, "deep blue."

Discovered by Herschel.

Pos. 152° 12′ Dist. 6″.28 Epoch 1833.14 Strüve.

26 Herschel IV, Eridani.—A. R. = 4 h. 06 m. 50 s. Dec. = — 13° 09′ 1″ A planetary nebula under the *N. F.* bend of the River.

Discovered by Herschel, in 1784, who saw it slightly elliptical, and thought it might be a globular cluster at an immense distance.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. VI.

AURIGA—THE WAGONER.

Favorably situated for examination in December, January, February and March.

AURIGA.

THE Charioteer, called also the Wagoner, is represented on the celestial map by the figure of a man in a reclining posture, resting one knee upon the horn of Taurus, with a goat and her kids in his right hand, and a bridle in his left.

It is situated N. of Taurus and Orion, between Perseus on the W. and the Lynx on the E. Its mean declination is 45° N.; so that when on the meridian, it is almost directly over head in New England. It is on the same meridian with Orion, and culminates at the same hour of the night. Both of these constellations are on the meridian at 9 o'clock on the 24th of January, and 1 hour and 40 minutes east of it on the 1st of January.

The whole number of visible stars in Auriga is sixty-six, including one of the 1st and one of the 2d magnitude, which mark the shoulders. *Capella*, α Aurigæ, is the principal star in this constellation, and is one of the most brilliant in the heavens. It takes its name from Capella, the goat, which hangs upon the left shoulder. It is situated in the west shoulder of Auriga, 24° E. of Algol, and 28° N. E. of the Pleiades. It may be known by a little sharp-pointed triangle formed by three stars, 3° or 4° this side of it, on the left. It is also 18° N. of β Tauri, which is common to the northern horn of Taurus, and the right foot of Auriga. Capella comes to the meridian on the 19th of January, just 2½ minutes before β, in the foot of Orion, which it very much resembles in brightness.

Menkalina, β Aurigæ, in the east shoulder, is a star of the 2d magnitude, 7½° E. of Capella, and culminates the next minute after Betelguese, α Orionis, 37¾° S. of it. θ, in the right leg, is a star of the 4th magnitude, 8° directly south of Menkalina.

It may be remarked as a curious coincidence, that the two stars in the shoulders of Auriga are of the same magnitude, and just as far apart as those in Orion, and opposite to them. Again, the two stars in the shoulders of Auriga, with the two in the shoulders of Orion, mark the extremities of a long, narrow parallelogram, lying N. and S., and whose length is just five times its breadth. Also, the two stars in Auriga, and the two in Orion, make two slender and similar triangles, both meeting in a common point, half way between them, at β, in the northern horn of Taurus.

Delta, a star of the 4th magnitude in the head of Auriga, is about 9° N. of the two in the shoulders, with which it makes a triangle, about half the hight of those just alluded to, with the vertex at Delta. The two stars in the shoulders are therefore the base of two similar triangles, one extending about 9° N., to the head, the other 18° S., to the heel, on the top of the horn: both figures together resembling an elongated diamond.

Delta in the head, β in the right shoulder, and θ in the arm of Auriga, make a straight line with Betelguese in Orion, δ in the square of the Hare, and β in Noah's Dove; all being very nearly on the same meridian, 4° W. of the solstitial colure.

> "See next the Goatherd with his kids; he shines
> With seventy stars, deducting only four,
> Of which Capella never sets to us,
> And scarce a star with equal radiance beams
> Upon the earth: two other stars are seen
> Due to the second order."—*Eudosia.*

TELESCOPIC OBJECTS.

ω Aurigæ.—A. R. = 4 h. 48 m. 24 s. Dec. = + 37° 38′ 5″. A double star preceding the hip of Auriga. A 5. pale red; B 9, light blue.

Discovered by Sir W. Herschel, who records the following measures.

Pos. = 352° 37′	Dist. = 5″.50	Epoch 1779.85	
351 56	6 .46	1828.75	Strüve.

Though the distances recorded by Herschel differ from the later ones, there is no reason to believe that the difference is due to an actual change in the places of these two stars. Herschel's means of making measures were less perfect than those now in use; and his measures are less to be relied on, from this cause.

5 Aurigæ.—A little north, and following ω Aurigæ. A delicate double star. A 6, B 10 magnitude.

Discovered by Strüve, with the Polkova refractor.

A Close Double Star.—A. R. = 4 h. 57 m. 11 s. Dec. = + 37° 08′ 4″. On the lower garment of Auriga. A 7, B 8 magnitude, near a loose cluster.

Discovered by Strüve, whose measures stood as follows:

Pos. 219° 12′ Dist. = 1″.61 Epoch 1828.60

14 Aurigæ.—A. R. = 5 h. 04 m. 59 s. Dec. = + 32° 29′ 8″. A triple star in the right knee of Auriga. A 5, B 7½, C 16 magnitude. A and B have been long known, C was recently added by Prof. Strüve. He records these measures.

A B	Pos.	225° 48′	Dist.	14″.653	Epoch 1830.55
A C		342 37		12 .577	1830.55

A Cluster.—A. R. = 5 h. 17 m. 18 s. Dec. = + 35° 10′ 3″. On the robe under the left thigh of Auriga. This object is about 3′ in diameter, and is composed of stars of various magnitudes, from the 10th to the 14th. It is preceded by a small double star. A 9½, B 11 magnitude. Dist. 5″.00

Discovered by Herschel, 1787.

A Rich Cluster.—A. R. = 5 h. 18 m. 41 s. Dec. = + 35° 41′ 9″. On the left thigh of Auriga.

Discovered by Messier, 1764, and described by him as "a mass of stars of a square form, without any nebulosity, extending to about 15′ of one degree."

A Resolvable Nebula.—A. R. = 5 h. 20 m. 51 s. Dec. = + 34° 06′ 9″. On the lower garment of Auriga.

Discovered by Herschel in 1793, who says that it seems to have one or two stars in the middle, or an irregular nucleus.

A Fine Cluster.—A. R. = 5 h. 41 m. 46 s. Dec. = + 32° 30′ 1″. In front of Auriga's left shin.

Discovered by Messier, 1764, and described as "a mass of small stars in nebulous matter."

θ Auriga.—A. R. = 5 h. 48 m. 48 s. Dec. + 37° 11′ 7″. A fine double star in the left wrist. A 4, lilac; B 10, pale yellow.

Pos. 289° 0′ Dist. 30″.00 Epoch 1832.64

41 Aurigæ.—A. R. = 5 h. 59 m. 21 s. Dec. = + 48° 44′ 1″. On the chin of Auriga. A 7, white; B 7½, violet.

Pos. 353° 07′ Dist. 7″.99 Epoch 1830.31 Strüve.

Many other double and triple stars, nebulæ and clusters, may be found on the charts, and by alignment their places in the heavens may be readily made out.

A [illegible] DOUBLE STAR.—A. R. = 4 h. 52 m. 11 s. Dec. = + [illegible]. On the [illegible] of Auriga. A 7 [illegible] 8 magnitude, [illegible] [illegible].

[illegible] whose components stood as follows:

[illegible] Dist. = [illegible] Epoch 1830.91

[illegible].—R. [illegible] 50 m. 59 s. Dec. = + [illegible]. In the right [illegible] of Auriga. [illegible] magnitude. [illegible] been long known, [illegible] measurement, by first [illegible], [illegible] the components:

[illegible] 1780.[illegible] Epoch 1830.[illegible]
[illegible] 22.[illegible] 1836.[illegible]

A [illegible].—R. [illegible] 17 m. 18 s. Dec. = + [illegible]. [illegible] the [illegible] of Auriga. This [illegible] [illegible] composed of stars [illegible] magnitudes, from the 10th [illegible]. It is [illegible] by a small [illegible] [illegible].

[illegible] by Herschel, 1783.

A [illegible].—A. R. = 5 h. 19 m. [illegible] s. Dec. = + [illegible] [illegible] of Auriga.

[illegible] by Messier, [illegible], and described by him as "a [illegible] of [illegible] stars, without any nebulosity, extending to about [illegible] of [illegible]."

A [illegible] NEBULA.—R. = 5 h. 20 m. [illegible] s. Dec. = + [illegible]. [illegible] the lower [illegible] of Auriga.

Discovered by Herschel in 1783, who says that it seemed to [illegible] [illegible] as the [illegible] on [illegible].

A [illegible] CLUSTER.—A. R. = 5 h. [illegible] m. 18 s. Dec. = + [illegible] [illegible] Auriga's [illegible].

Discovered by Messier, 1764, and described as "a mass of small stars in [illegible]."

A [illegible].—A. R. = [illegible] s. Dec. = + [illegible]. A [illegible] star in the [illegible]. A [illegible] [illegible], pale yellow.

[illegible] Dist. [illegible] Epoch 1830.[illegible]

[illegible].—A. R. = [illegible] m. [illegible] s. Dec. = + [illegible]. In the [illegible] of Auriga. [illegible] [illegible] violet.

[illegible] [illegible] Dist. [illegible] Epoch 1830.[illegible] Struve.

[illegible] [illegible] and purple [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] by [illegible] their [illegible] [illegible] the [illegible] [illegible] be [illegible].

CHAPTER II.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. VII.

GEMINI—THE TWINS.
CANCER—THE CRAB.
CANIS MINOR—THE LITTLE DOG.

Favorably situated for examination in January, February, March and April.

GEMINI.

THE TWINS.—This constellation represents the twin brothers, Castor and Pollux.

Gemini is the *third sign*, but *fourth constellation* in the order of the Zodiac, and is situated south of the Lynx, between Cancer on the east and Taurus on the west. The orbit of the earth passes through the center of the constellation. As the earth moves round in her orbit from the first point of Aries to the same point again, the sun, in the meantime, will *appear* to move through the *opposite* signs, or those which are situated right over against the earth, on the other side of her orbit.

Accordingly, if we could *see* the stars as the sun appeared to move by them, we should see it passing over the constellation Gemini between the 21st of June and the 23d of July; but we seldom see more than a small part of any constellation through which the sun is then passing, because the feeble luster of the stars is obscured by the superior effulgence of the sun.

When the sun is just entering the outlines of a constellation on the east, its western limits may be seen in the morning twilight, just above the rising sun. So when the sun has arrived at the western limit of a constellation, the eastern part of it may be seen lingering in the evening twilight, just behind the setting sun. Under other circumstances, when the sun is said to be in, or to enter, a particular constellation, it is to be understood that the constellation is not then visible, but that those opposite to it, are. For example: whatever constellation sets with the sun on any day, it is plain that the one opposite to it must be then rising, and continue visible throughout the night. Also, whatever constellation rises and sets with the sun to-day, will, six months hence, rise at sun-setting, and set at sun-rising. For example: the sun is in the center of Gemini about the 6th of July, and must rise and set with it on that day; consequently, six months from that time, or about the 4th of January, it will rise in the east, just when the sun is setting in the west, and will come to the meridian at midnight; being then exactly opposite to the sun.

Now as the stars gain upon the sun at the rate of two hours every month, it follows that the center of this constellation will, on the 17th of February, come to the meridian three hours earlier, or at 9 o'clock in the evening.

It would be a pleasant exercise for students to propose questions to each other, somewhat like the following:—What zodiacal constellation will rise and set with the sun to-day? What one will rise at sun-setting? What constellation is three hours high at sun-set, and where will it be at 9 o'clock? What constellation rises two hours before the sun? How many days or months hence, and what hour of the evening or morning, and in what part of the sky shall we see the constellation whose center is now where the sun is? &c., &c.

In solving these and similar questions, it may be remembered that the sun is in the vernal equinox about the 21st of March, from whence it advances through one sign or constellation every succeeding month thereafter; and that each *constellation* is one month in advance of the *sign* of that name: wherefore, reckon Pisces in March, Aries in April, Taurus in May, and Gemini in June, &c.; beginning with each constellation at the 21st, or 22d of the month.

Gemini contains eighty-five stars, including two of the 2d, four of the 3d, and six of the 4th magnitudes. It is readily recognised by means of the two principal stars, *Castor* and *Pollux*, α and β, of the 2d magnitude, in the head of the Twins, about $4\frac{1}{2}°$ apart.

There being only 11 minutes difference in the transit of these two stars over the meridian, they may both be considered as culminating at 9 o'clock about the 24th of February. *Castor*, in the head of Castor, is a star of the 2d magnitude, $4\frac{1}{2}°$ N. W.

of Pollux, and is the northernmost and the brightest of the two. *Pollux* is a star of the 2d magnitude, in the head of Pollux, and is $4\frac{1}{2}°$ S. E. of Castor. This is one of the stars from which the moon's distance is calculated in the Nautical Almanac.

> —— "Of the famed Ledean pair,
> One most illustrious star adorns their sign,
> And of the second order shine twin lights."

The relative magnitude or brightness of these stars has undergone considerable changes at different periods; whence it has been conjectured by various astronomers that Pollux must vary from the 1st to the 3d magnitude. But Herschel, who observed these stars for a period of twenty-five years, ascribes the variation to Castor, which he found to consist of two stars, very close together, the less revolving about the larger once in 342 years and two months.

Bradly and Maskelyne found that the line joining the two stars which form Castor was, at all times of the year, parallel to the line joining Castor and Pollux; and that both of the former move around a common center between them, in orbits nearly circular, as two balls attached to a rod would do, if suspended by a string affixed to the center of gravity between them.

"These men," says Dr. Bowditch, "were endowed with a sharpness of vision, and a power of penetrating into space, almost unexampled in the history of astronomy."

About 20° S. W. of Castor and Pollux, and in a line nearly parallel with them, is a row of stars 3° or 4° apart, chiefly of the 3d and 4th magnitudes, which distinguish the feet of the twins. The brightest of these is *Alhena*, γ, in Pollux's upper foot; the next small star S. of it, is in his other foot: the two upper stars in the line next above γ, mark Castor's feet.

This row of feet is nearly two-thirds of the distance from Pollux to Betelguese in Orion, and a line connecting them will pass through Alhena, the principal star in the feet. About two-thirds of the distance from the two in the head to those in the feet, and nearly parallel with them, there is another row of three stars about 6° apart, which mark the knees.

There are, in this constellation, two other remarkable parallel rows, lying at right angles with the former; one, leading from the head to the foot of Castor, the brightest star being in the middle, and in the knee; the other, leading from the head to the foot of Pollux, the brightest star, called Wasat, δ, being in the body, and ζ. next below it, in the knee.

Wasat is in the ecliptic, and very near the center of the constellation. The two stars, μ and Tejat, η, in the northern foot, are also very near the ecliptic: Tejat is a small star of between the 4th and 5th magnitudes, 2° W. of μ, and deserves to be noticed because it marks the spot of the summer solstice, in the tropic of Cancer, just where the sun is, on the longest day of the year, and is moreover, the dividing limit between the torrid and the N. temperate zone.

Propus, also in the ecliptic, 2½° W. of η, is a star of only the 5th magnitude, but rendered memorable as being the star which served for many years to determine the position of the planet Herschel, after its first discovery.

Thus as we pursue the study of the stars, we shall find continually new and more wonderful developments to engage our feelings and reward our labor. We shall have the peculiar satisfaction of reading the same volume that was spread out to the patriarchs and poets of other ages, of admiring what they admired, and of being led as they were led, to look upon these lofty mansions of being as having, above them all, a common Father with ourselves, "who ruleth in the armies of heaven, and bringeth forth their hosts by number."

TELESCOPIC OBJECTS.

A Rich Cluster.—A. R. = 5 h. 59 m. 01 s. Dec. = 24° 21′ 3″. Near Castor's right foot. A very fine object, consisting of a crowd of stars from the 9th to the 16th magnitudes.

Discovered by Messier, 1764.

A Cluster.—A. R. = 6 h. 45 m. 56 s. Dec. = + 18° 10′ 5″. On the calf of the right leg of Pollux; consists of minute stars of the 12th and 16th magnitudes, arranged somewhat in the shape of a fan, as described by former observers.

Discovered by Sir W. Herschel, 1783.

λ Geminorum.—A. R. = 7 h. 08 m. 54 s. Dec. = + 16° 49′ 5″. A fine double star on the left thigh of Pollux. A 4½, white; B 12, yellowish.

Discovered by Strüve, and thus measured.

Pos. 30° 55′ Dist. 9″.56 Epoch 1829.86

δ Geminorum.—A. R. = 7 h. 10 m. 34 s. Dec. = + 22° 16′ 3 . A double star on the right hip of Pollux. A 3½, "pale white;" B 9, "purple."

Discovered by Herschel, 1781.

Pos. 196° 54′ Dist. 7″.15 Epoch 1829.72 Strüve.

κ Geminorum.—A. R. = 7 h. 34 m. 47 s. Dec. = + 24° 46′ 5 A double star on the left shoulder of Pollux. A 4, orange; B 10, pale blue. The minute companion of this star was pointed out as one of a few which Sir John Herschel thought deserved particular attention, to determine whether it might not be a *satellite shining by reflected light.*

Discovered by Herschel, with his twenty feet reflector.

Pos. 231° 9′ Dist. 6″.0 Epoch 1838.98 Smyth.

61 Geminorum.—A. R. = 7 h. 17 m. 31 s. Dec. = +20° 34′ 3″. A coarse double and close double star, making a quadruple set in the loins of Pollux. A 7½, deep yellow; B 9, yellowish; C 8, blue; D 9, bluish.

D C Pos. = 42° 24′ Dist. = 6″.5 Epoch 1835.85 Smyth.

α Geminorum.—A. R. = 7 h. 24 m. 23 s. Dec. = + 32° 14′. A beautiful double star in the head of Castor, and named Castor. A 3, B 3½, magnitude. This is one of the interesting *binary stars.* The earliest position on record is by Bradly and Pound.

Pos. 355° 53′ Epoch 1719.84

This is deduced from the recorded position of the line joining the center of the components of Castor, with reference to a third star of the 11th magnitude; distant about 72″. In 1800, Sir W. Herschel made the pos. = 293° 03′, since then we find, among others, these measures.

Pos.	261° 01′	Dist. 4″.358	Epoch 1828.89	Strüve.
	256 07	5 .280	1836.88	Encke, Galle.
	252 49	4 .886	1841.11	Mädler.

Mädler has computed the elements of the orbit of this star, and found for a probable period 232 years. There are, however, yet many difficulties in the way of reliable results, and computers differ. More observations are necessary to complete the examinations of this interesting binary system.

38 Geminorum.—A. R. = 6 h. 45 m. 37 s. Dec. = + 13° 22′ 6″. A double star on the left instep of Pollux. A 5½, B 8, magnitude. The large star yellow, the small one purple.

Discovered by Herschel in 1781.

Pos.	179° 54′	Dist. 7″.95	Epoch 1781.99	Herschel.
	174 53	5 .73	1829.24	Strüve.
	172 02	6 .42	1841.27	Mädler.

Mädler thinks this system may be binary, in which case its periodic time cannot fall much below 3000 years.

A Cluster.—A. R. = 7 h. 28 m. 57 s. Dec. = + 21° 55′ 7″ On the left shoulder of Pollux.

Discovered by Herschel in 1783, and described as "a beautiful cluster of many large and compressed small stars, about 12′ in diameter."

CANCER.

The Crab is now the fifth constellation and fourth sign of the Zodiac. It is situated in the ecliptic, between Leo on the E. and Gemini on the W. It contains eighty-three stars, of which two are of the 4th magnitude.

Beta is a star of the 4th magnitude, in the southwestern claw, 10° N. E. of Procyon, α Canis Minoris, and may be known from the fact that it stands alone, or at least has no star of the same magnitude near it. It is midway between Procyon and Acubens.

Acubens, α, is a star of the 5th magnitude, in the southeastern claw, 10° N. E. of Beta, and nearly in a straight line with it and Procyon. It may be otherwise distinguished by its standing between two very small stars close by it in the same claw.

Tegmine, ζ, the last in the back, appears to be a small star, of between the 5th and 6th magnitudes, 8½° in a northerly direction from Beta. It is a treble star, and to be distinctly seen, requires very favorable circumstances. Two of them are so near together that it requires a telescopic power of 300 to separate them.

About 7° northeasterly from Tegmine, is a nebulous cluster of very minute stars, in the crest of Cancer, sufficiently luminous to be seen by the naked eye. It is situated in a triangular position with regard to the head of the Twins and the Little Dog. It is about 20° W. of each. It may otherwise be discovered by means of two conspicuous stars of the 4th magnitude lying one on either side of it, at the distance of about 2°, called the *northern* and *southern Aselli*. By some of the Orientalists, this cluster was denominated *Præsepe*, the *Manger*, a contrivance which their fancy fitted up for the accommodation of the *Aselli* or *Asses;* and it is so called by modern astronomers. The appearance of this nebula to the unassisted eye, is not unlike the nucleus of a comet, and it was repeatedly mistaken for the comet of 1832, which, in the month of November, passed in its neighborhood.

The southern Asellus, marked δ, is situated in the line of the ecliptic, and in connection with δ and Gemini, η, marks the course of the earth's orbit for a space of 36° from the solstitial colure.

There are several other double and nebulous stars in this constellation, most of which are too small to be seen; and indeed, the whole constellation is less remarkable for the brilliancy of its stars than any other in the Zodiac.

The sun arrives at the *sign* Cancer about the 21st of June, but does not reach the *constellation* until the 23d of July.

The mean right ascension of Cancer is 128°. It is consequently on the meridian the 3d of March.

A few degrees S. of Cancer, and about 17° E. of Procyon, are four stars of the 4th magnitude, 3° or 4° apart, which mark the head of Hydra.

The beginning of the *sign* Cancer (not the constellation) is called the *Tropic of Cancer*, and when the sun arrives at this point, it has reached its utmost limit of north declination, where it seems to remain stationary a few days, before it begins to decline again to the south. This stationary attitude of the sun is called the summer *solstice;* from two Latin words signifying the *sun's standing still.* The distance from the first point of Cancer to the equinoctial, which at present, is 23° 27⅔′, is called the *obliquity of the ecliptic.* It is a remarkable and well ascertained fact, that this is continually growing less and less. The tropics are slowly and steadily approaching the equinoctial, at the rate of about half a second every year; so that the sun does not now come so far north of the equator in summer, nor decline so far south in winter, as it must have done at the creation, by nearly a degree.

TELESCOPIC OBJECTS.

11 Cancri.—A. R. = 7 h. 59 m. 02 s. Dec. = + 27° 56′ 4″. A close double star between the head of Pollux and the preceding claw of Cancer. A 7, B 12, magnitude.

Pos. 218° 52′ Dist. 3″.18 Epoch 1828.26 Strüve.

ζ Cancri.—A. R. = 8 h. 03 m. 02 s. Dec. = + 18° 07′ 5″. A fine triple star just below the following claw of Cancer. A 6, yellow; B 7, orange; C 7½, yellowish.

Discovered by the elder Herschel.

	Pos.	Dist.	Epoch	
A B	3° 28′	= 1″.00	1781.90	Herschel.
A C	181 44	8 .05	1781.90	
A B	21 30	1 .13	1833.27	Strüve.
A C	148 18	5 .48	1833.27	
A B	1 01 6″	1 .050	1841.31	Mädler.
A C	147 54	5 .008	1841.31	

This is a very remarkable object. Captain Smyth deduced a period for A and B of sixty years, while C performs its revolution about the other two in 500 or 600 years. Here is a ternary system; three suns revolving about their common center of gravity, and doubtless each attended by a retinue of planets. How wonderful must be the heavens to the inhabitants of the planets attached to this triple system. Imagine a yellow sun rising, an orange one on the meridian, while a purple or blue, or red one, may be in the act of sinking below the horizon! Again, the powerful analysis with which man urges his way through the intricacies of our simple solar system, would utterly fail to trace the career of a planet subjected to the contending influences of three grand orbs like the sun. May we not infer, from this fact, the existence of races of a higher order of intellect in the planets of these ternary systems?

φ 2 Cancri.—A. R. = 8 h. 17 m. 6 s. Dec. = + 27° 27′ 2″. A close double star above the northern legs of Cancer. A 6, B 6½, magnitude. Its position is probably fixed.

Pos. 212° 01′ Dist. 4″.563 Epoch 1829.45 Strüve.

ν 1 Cancri.—A. R. = 8 h. 17 m 08 s. Dec. = + 25° 03′ 3″. A double star on the crab's northern middle leg. A 7. B 7½.

Discovered by Herschel, 1782. Measured by him as follows:

Pos. 57° 51′ Epoch 1783.07 Herschel.

In 1822, Sir James South and Sir John Herschel found the position to be 37° 47′, whence a rapid retrograde motion was inferred, but all subsequent measures disprove this inference, and indicate a direct motion.

Pos. 39° 04′ Dist. 5″.723 Epoch 1841.35 Mädler.

δ Cancri —A. R. = 8 h. 35 m. 35 s. Dec. = + 18° 44′ 4″. A difficult double star under the crab's mouth. A 4½, B 15, magnitude.

ι Cancri.—A. R. = 8 h. 37 m. 00 s. Dec. = 29° 20′ 4″. A double star at the end of the crab's northern claw. A 5½, pale orange; B 8. clear blue. This is the first double star I ever saw. In July 1842, I had the pleasure of examining it at the observatory of Sir James South, Kensington. The colors were distinct and beautifully contrasted.

Pos. 307° 06′ Dist. 30″.46 Epoch 1828.04 Strüve.

No material change has occurred in fifty-four years, the time since its discovery by Herschel.

67 Messier, Cancri.—A. R. = 8 h. 42 m. 26 s. Dec. = + 12° 23′ 6″. A rich but scattered cluster, at the root of the southern claw of Cancer. It is readily resolved, and with a power of 157 Herschel counted two hundred stars of various magnitudes, from the 9th to the smallest magnitude. I have frequently examined this splendid object, and from its appearance suppose it to be one of the near "island universes."
Discovered by Messier, 1780.

σ 2 Cancri.—A. R. = 8 h. 44 m. 28 s. Dec. = + 31° 10′ 9″. A close double star over the crab's northern claw. A 5½, B 7 magnitude.
Discovered by Sir W. Herschel. 1782.
Pos. 333° 18′ Dist. = 1″.51 Epoch 1829.71 Strüve.
There is little evidence of any change of position, though the measures recorded are far from coincident.

σ 4 Cancri.—A. R. = 8 h. 51 m. 35 s. Dec. = + 32° 52′ 4″. A close double star, following the crab's northern claw. A 6, white; B 9, blue.
Discovered by South, 1825.
Pos. 137° 47′ Dist. 4″.50 Epoch 1831.16 Strüve.

CANIS MINOR.

The Little Dog.—This small constellation is situated about 5° N. of the equinoctial, and midway between Canis Major and the Twins. It contains fourteen stars, of which two are very brilliant. The brightest star is called *Procyon*, marked α. It is of the 1st magnitude, and is about 4° S. E. of the next brightest, *Gomelza*, marked β, which is of the 3d magnitude.

These two stars resemble the two in the head of the Twins. Procyon, in the Little Dog, is 23° S. of Pollux in Gemini, and Gomelza is about the same distance S. of Castor.

A great number of geometrical figures may be formed of the principal stars in the vicinity of the Little Dog. For example; Procyon is 23° S. of Pollux, and 26° E. of Betelguese, and forms with them a large right angled triangle. Again, Procyon is equidistant from Betelguese and Sirius, and forms with them an equilateral triangle whose sides are each about 26°. If a straight line, connecting Procyon and Sirius, be produced 23° farther, it will point out Phaet, in the Dove.

Procyon is often taken for the name of the Little Dog, or for the whole constellation, as Sirius is for the greater one; hence it is common to refer to either of these constellations by the name of its principal star. Procyon comes to the meridian fifty-three minutes *after* Sirius, on the 24th of February; although it rises, in this latitude, about half an hour *before* it. For this reason, it was called *Procyon*, from two Greek words which signify (*Ante Canis*) "before the dog."

> "Canicula, fourteen thy stars; but far
> Above them all, illustrious through the skies,
> Beams *Procyon*: justly by Greece thus called
> The bright *forerunner* of the *greater Dog*."

From an irregularity in the annual proper motion of Procyon, Bessel concluded that it was disturbed by some invisible opaque body of vast size, sunk in space, near Procyon. Strüve has recently cast a doubt on the reality of this irregularity, and thinks it is due to imperfect observations.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. VIII.

MONOCEROS—THE UNICORN.
CANIS MAJOR — THE GREAT DOG.
LEPUS—THE HARE.
THE PRINTING PRESS.

Favorably situated for examination in January, February and March.

MONOCEROS.

THE UNICORN.—This is a modern constellation, which was made out of the unformed stars of the ancients that lay scattered over a large space of the heavens between the two Dogs. It extends a considerable distance on each side of the equinoctial, and its center is on the same meridian with Procyon.

It contains thirty-one small stars, of which the seven principal ones are of only the 5th magnitude. Three of these are situated in the head, 3° or 4° apart, forming a straight line N. E. and S. W. about 9° E. of Betelguese, in Orion's shoulder, and about the same distance S. of Alhena, in the foot of the Twins.

The remaining stars in this constellation are scattered over a large space, and being very small, are unworthy of particular notice.

TELESCOPIC OBJECTS.

104 P. VI, MONOCEROTIS.—A. R. = 6 h. 18 m. 30 s. Dec. = + 0° 32′ 6″. A coarse triple, or close double star. A 7½, B and C, each 8½ magnitude. As A and B are 66″ apart, we shall only have to do with B and C. This is one of Strüve's "vincinissemæ" stars. He reports these measures.

Pos. 168° 48′ Dist. 0″.78 Epoch 1825.12

11 MONOCEROTIS.—A. R. = 6 h. 21 m. 04 s. Dec. = — 6° 56′ 1″.

A fine triple star in the right fore leg of Monoceros. A 6½, B 7, C 8, magnitude.

Discovered by Sir W. Herschel, and by him said to be one of the most beautiful sights in the heavens.

A B Pos. 101° 44′	Dist. 2″.463	Epoch 1831.23	Strüve.
A B 103 41	2 .557	1842.21	Mädler.
A C 310 00	7 .253	1831.23	Strüve.
A C 311 23	7 .205	1842.21	Mädler.
B C 304 40	9 .452	1842.21	Mädler.

Mädler thinks this may prove to be a triple system, in which case the observations would indicate for A and B a period of nearly 17,000 years, and for B and C a period of more than 1,000 years.

14 Monocerotis.—A. R. = 6 h. 26 m. 06 s. Dec. = + 7° 41′ 5″. A difficult double star in the eye of the Unicorn. A 6, B 16, magnitude. Smyth's estimates are follows:

Pos. 210° 0′ Dist. 10″.0 Epoch 1833.87

15 Monocerotis.—A. R. = 6 h. 32 m. 10 s. Dec. = + 10° 02′ 2″. A triple star between the ears of Monoceros. A 6, "greenish;" B 9, "pale grey;" C 15, "blue."

Discovered by Strüve.

Pos. A B 208° 66′	Dist. 2″.76	Epoch 1831.37	Strüve.
A C 12 90	16 .38	1831.37	

50 Messier, Monocerotis.—A. R. = 6 h. 55 m. 11 s. Dec. = — 8° 06′ 7″. A large cluster in the Milky Way, on the Unicorn's right shoulder, composed of stars varying from the 8th to the 16th magnitude Discovered by Messier, 1771.

CANIS MAJOR.

The Great Dog.—This interesting constellation is situated southward and eastward of Orion, and is universally known by the brilliancy of its principal star, *Sirius*, marked α, which is apparently the largest and brightest in the heavens. It glows in the winter hemisphere with a luster which is unequaled by any other star in the firmament.

Its distance from the earth, though computed at twenty millions of millions of miles, has been considered less than that of any other star: a distance, however, so great that a cannon ball, which flies at the rate of nineteen miles a minute, would be two millions of years in passing over the mighty interval; while sound, moving at the rate of thirteen miles a minute, would reach Sirius in little less than three millions of years.

It may be shown in the same manner, that a ray of light, which occupies only eight minutes and thirteen seconds in coming to us from the sun, which is at the rate of nearly two hundred thousand miles a second, would be three years and eighty-two days in passing through the vast space that lies between Sirius and the earth. Consequently, were it blotted from the heavens, its light would continue visible to us for a period of three years and eighty-two days after it had ceased to be.

If the *nearest* stars give such astonishing results, what shall we say of those which are situated a thousand times as far *beyond* these, as these are from us?

In the remote ages of the world, when every man was his own astronomer, the rising and setting of Sirius, or the *Dog-star*, as it is called, was watched with deep and various solicitude. The ancient Thebans, who first cultivated astronomy in Egypt, determined the length of the year by the number of its risings. The Egyptians watched its rising with mingled apprehensions of hope and fear; as it was ominous to them of agricultural prosperity or blighting drought. It foretold to them the rising of the Nile, which they called *Siris*, and admonished them when to sow. The Romans were accustomed yearly, to sacrifice a dog to Sirius to render him propitious in his influence upon their herds and fields. The eastern nations generally believed the rising of Sirius would be productive of great heat on the earth.

Thus Virgil:

———"Tum steriles exurere Sirius agros:
Ardebant herbæ, et victum seges ægra negabat."

———"Parched was the grass, and blighted was the corn.
Nor 'scape the beasts; for Sirius, from on high,
With pestilential heat infects the sky."

Accordingly, to that season of the year when Sirius rose with the sun and seemed to blend its own influence with the heat of that luminary, the ancients gave the name of *Dog-days*, (*Dies Caniculares*). At that remote period the Dog-days commenced on the 4th of August, or four days after the summer solstice, and lasted forty days, or until the 14th of September. At present the Dog-days begin on the 3d of July, and continue to the 11th of August, being one day less than the ancients reckoned.

Hence, it is plain that the Dog-days of the moderns have no reference whatever to the rising of Sirius, or any other star, because the *time* of their rising is perpetually accelerated by the precession of the equinoxes: they have reference then only to the summer solstice, which never changes its position in respect to the seasons.

The time of Sirius' rising varies with the latitude of the place, and in the same latitude, is sensibly changed after a course of years, on account of the precession at the equinoxes. This enables us to determine with approximate accuracy, the dates of many events of antiquity, which cannot be well determined by other records. We do not know, for instance, in what precise period of the world Hesiod flourished. Yet he tells us, in his *Opera et Dies*, lib. ii. v. 185, that Arcturus in his time rose heliacally, sixty days after the winter solstice, which then was in the 9th degree of Aquarius, or 39° beyond its present position. Now $39^\circ : 54\frac{1}{4}'' = 2794$ years since the time of Hesiod, which corresponds very nearly with history.

When a star rose at sun-setting, or set at sun-rising, it was called the *Achronical* rising or setting. When a planet or star appeared above the horizon just before the sun, in the morning, it was called the *Heliacal* rising of the star; and when it sunk below the horizon immediately after the sun, in the evening, it was called the *Heliacal* setting. According to Ptolemy, stars of the *first* magnitude are seen rising and setting when the sun is 12° below the horizon; stars of the 2d magnitude require the sun's depression to be 13°; stars of the 3d magnitude, 14°, and so on, allowing one degree for each magnitude. The rising and setting of the stars described in this way, since this mode of description often occurs in Hesiod, Virgil, Columella, Ovid, Pliny, &c., are called *poetical* rising and setting. They served to mark the times of religious ceremonies, the seasons allotted to the several departments of husbandry, and the overflowing of the Nile.

The student may be perplexed to understand how the Dog-star, which he seldom sees till mid-winter, should be associated with the most fervid heat of summer. This is explained by considering that this star, in summer, is over our heads in the *day-time*, and in the lower hemisphere at night. As "thick the floor of heaven is inlaid with patines of bright gold," by day, as by night; but on account of the superior splendor of the sun, we cannot see them.

Sirius is easily recognised, being the brightest star in the heavens, and is pointed out by the direction of the Three Stars in the belt of Orion. Its distance from them is about 23°. It comes to the meridian at 9 o'clock on the 11th of February.

Mirzam, marked β, in the foot of the Dog, is a star of the 2d magnitude, $5\frac{1}{2}°$ W. of Sirius. A little above, and 4° or 5° to the left, there are three stars of the 3d and 4th magnitudes, forming a triangular figure somewhat resembling a dog's head. The brightest of them, on the left, is called *Muliphen*, marked γ. It entirely disappeared in 1670, and was not seen again for more than twenty years. Since that time it has maintained a steady luster.

Wesen, marked δ, is a star of the 3d magnitude, in the back, 11° S. S. E. of Sirius, with which, and Mirzam in the paw, it makes an elongated triangle. The two hinder feet are marked by Naos and Lambda, stars of the 3d and 4th magnitudes, situated about 3° apart, and 12° directly S. of the fore foot. This constellation contains thirty-one visible stars, including one of the 1st magnitude, four of the 2d, and two of the 3d; all of which are easily traced out by the aid of the map.

TELESCOPIC OBJECTS.

ν 1 Canis Majoris.—A. R. = 6 h. 29 m. 23 s. Dec. = — 18° 32′ 0″. A double star in the Greater Dog's left knee, about 3° south-west of Sirius. A $6\frac{1}{2}$, B 8, magnitude.

Pos. 261° 36′ Dist. 17″.34 Epoch 1842.82 Main.

α Canis Majoris, Sirius.—A. R. = 6 h. 38 m. 06 s. Dec. = — 16° 30′ 1″. A star of the first magnitude in the mouth of the Greater

Dog, the most brilliant of all the fixed stars. The telescopic appearance of this object must be seen to be appreciated. Long before it enters the field of the telescope, its coming is indicated by a gradually brightening dawn, which slowly increases in splendor, until the star enters with its full blaze, too powerful to be borne by the sight.

Its entrance and disappearance resemble the rising and setting of the sun.

Sirius was long regarded as the nearest of all the fixed stars, from its exceeding brilliancy. Long and delicate measures have been made to determine its parallax, but without satisfactory results. Yet its proper motion is great, and readily deduced from a few years of observations. On a comparison of the place of Sirius, as laid down by the earliest Greek astronomers, with its present position, and computing the changes due to the present rate of proper motion. Bessel deduces the curious fact that the annual proper motion is *not uniform!* This is true of a few other fixed stars. To account for this phenomenon, Bessel conceives that Sirius is subjected to the influence of some vast body, which, from the fact of its being non-luminous, has never been discovered. How wonderful would it be, if by a rigid scrutiny of the deviations of the proper motions of Sirius from uniformity, we should be led to a knowledge of the position in space of this dark disturbing body, of whose place and existence, indeed, the sight can reveal to us nothing.

The latest and best measures for parallax are by Henderson and McLear, who found for the angle subtended by the radius of the earth's orbit, at a distance equal to Sirius 0″.23, or about one quarter of one second of space. In case we adopt this as the true parallax, the distance of Sirius must be nearly eighty millions of millions of miles, and from its splendor we are able to infer, with certainty, that its magnitude is very much greater than that of our sun. Indeed, Dr. Walliston, assuming the distance to be but half the above, concludes from his photometrical measures, that Sirius, if seen as near as the sun, would present a diameter four times greater than that of the sun.

μ Canis Majoris.—A. R. = 6 h. 48 m. 46 s. Dec. = — 13° 50′ 5″. A double star on the Dog's right ear. A 5½, yellow; B 9½, grey.
Discovered by Strüve, who gives these measures.
Pos. 343° 31′ Dist. 3″.22 Epoch 1831.30

14 Herschel, VII Canis Majoris.—A. R. = 6 h. 52 m. 10 s. Dec. = — 13° 29′ 2″. A cluster of stars back of the Dog's head, about 20′ in diameter. The stars range from the 8th to the 11th magnitude.
Discovered by Herschel.

12 Herschel, VII Canis Majoris.—A. R. = 7 h. 10 m. 35 s. Dec. = — 15° 21′ 4″. A cluster of stars between the Dog and Unicorn; and consists principally of stars of the 10th magnitude.
Discovered by Miss Herschel.

LEPUS.

THE HARE.—This constellation is situated directly south of Orion, and comes to the meridian at the same time; namely, on the 24th of January. It has a mean declination 18° S. and contains nineteen small stars, of which, one is of the 2d, one of the 3d, and six of the 4th magnitudes. It may be readily distinguished by means of four stars of the 3d magnitude, in the form of an irregular square, or trapezium.

Zeta, of the 4th magnitude, is the first star, and is situated in the back, 5° S. of Saiph, in Orion. About the same distance below ζ are the four principal stars, in the legs and feet. These form the square. They are marked $\alpha, \beta, \gamma, \delta$. α and β, otherwise called *Arneb*, form the N. W. end of the trapezium, and are about 3° apart. γ and δ form the S. E. end, and are about $2\frac{1}{2}$° apart. The upper right hand one, which is Arneb, is the brightest of the four, and is near the center of the constellation. Four or five degrees S. of Rigel are four very minute stars, in the ears of the Hare.

TELESCOPIC OBJECTS.

ι LEPORIS.—A. R. = 5 h. 04 m. 50 s. Dec. = — 12° 03′ 9″. A double star in the left ear of the Hare. A $4\frac{1}{2}$, B 12, magnitude.

Pos. 359° 31′	Dist. 12″.34	Epoch 1782.69	Herschel.
337 39	12 .81	1832.25	Strüve.

κ LEPORIS.—A. R. = 5 h. 5 m. 51 s. Dec. = — 13° 08′ 0″. A double star at the root of the ear. A 5, B 9, magnitude.

Pos. 358° 68′	Dist. 3″.053	Epoch 1832.23	Strüve.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. IX.

LEO MAJOR—THE GREAT LION.
SEXTANS—THE SEXTANT.

Favorably situated for examination in March, April, and May.

LEO.

THE LION.—This is one of the most brilliant constellations in the winter hemisphere, and contains an unusual number of very bright stars. It is situated next E. of Cancer, and directly S. of Leo Minor and the Great Bear.

The Hindoo Astronomer, Varaha says. "Certainly the southern solstice was once in the middle of *Asleha* (*Leo*); the northern in the first degree of *Dhanishta*" (*Aquarius*). Since that time, the solstitial, as well as the equinoctial points, have gone backwards on the ecliptic 75°. This divided by 50¼", gives 5373 years; which carry us back to the year of the world 464. Sir W. Jones, says that Varaha lived when the solstices were in the first degrees of Cancer and Capricorn; or about 400 years before the Christian era.

Leo is the *fifth sign*, and the *sixth* constellation of the Zodiac. The mean right ascension of this extensive group is 150°, or 10 hours. Its center is therefore on the meridian the 6th of April. Its western outline, however, comes to the meridian on the 18th of March, while its eastern limit does not reach it before the 3d of May.

This constellation contains ninety-five visible stars, of which one is of the 1st magnitude, one of the 2d, six of the 3d, and fifteen of the 4th.

The principal star in this constellation is of the 1st magnitude, situated in the breast of the animal, marked α, and named *Regulus*, from the illustrious Roman consul of that name.

It is situated almost exactly in the ecliptic, and may be readily distinguished on account of its superior brilliancy. It is the largest and lowest of a group of five or six bright stars which form a figure somewhat resembling a sickle, in the neck and shoulder of the Lion. There is a little star of the 5th magnitude about 2° S. of it, and one of the 3d magnitude 5° N. of it, which will serve to point it out.

Regulus is the brightest star in the constellation. Great use is made of Regulus by nautical men, for determining their longitude at sea. Its *latitude*, or distance from the *ecliptic*, is less than $\frac{1}{2}$°; but its *declination*, or distance from the *equinoctial* is nearly 13° N.; so that its meridian altitude will be just equal to that of the sun on the 19th of August. Its right ascension is very nearly 150°. It therefore culminates about 9 o'clock on the 6th of April.

When Regulus is on the meridian, Castor and Pollux are seen about 40° N. W. of it, and the two stars in the Little Dog, are about the same distance in a S. W. direction; with which, and the two former, it makes a large isosceles triangle whose vertex is at Regulus.

The next considerable star, is 5° N. of Regulus, marked η, situated in the collar; it is of between the 3d and 4th magnitudes, and, with Regulus, constitutes the handle of the sickle. Those three or four stars of the 3d magnitude, N. and W. of η, arching round with the neck of the animal, describe the blade.

Al Gieba, marked γ, is a bright star of the 3d magnitude, situated in the shoulder, 4° in a N. E. direction from η, and may be easily distinguished by its being the brightest and middle one of the three stars lying in a semicircular form, curving towards the west; and it is the first in the blade of the sickle.

Adhafera, marked ζ, is a star of the 4th magnitude, situated in the neck, 4° N. of *Al Gieba*, and may be known by a very minute star just below it. This is the second star in the blade of the sickle.

Ras al Asad, marked μ, situated before the ear, is a star of the 3d magnitude, 6° W. of Adhafera, and is the third in the blade of the sickle. The next star, ε, of the same magnitude, situated in the head, is $2\frac{1}{2}$° S. W. of Ras al Asad, and a little *within* the curve of the sickle. About midway between these, and a little to the E., is a very small star, hardly visible to the naked eye.

Lambda, situated in the mouth, is a star of the 4th magnitude, $3\frac{1}{2}$° S. W. of ε, and the last in the sickle's point. *Kappa*, situated in the nose, is another star of the same magnitude, and about as far from λ as ε. ε and $\varkappa$ are about $5\frac{1}{2}$° apart, and form the longest side of a triangle, whose vertex is in $\varkappa$.

Zosma, marked δ, situated above the back of the Lion, is a star of the 3d magnitude, 18° N. E. of Regulus, and midway between it and Coma Berenices, a fine cluster of small stars, 18° N. E. of Zozma.

Theta, situated in the tail, is another star of the 3d magnitude, 5° directly S. of Zozma, and so nearly on the same meridian that it culminates but one minute after it. This star makes a right angled triangle with Zozma on the N., Denebola on the E., the right angle being at ϑ.

Nearly in a straight line with Zozma, and ϑ, and south of them, are three or four smaller stars, 4° or 5° apart, which mark one of the legs.

Denebola, marked β, is a bright star of the 2d magnitude, in the brush of the tail, 10° S. E. of Zozma, and may be distinguished by its great brilliancy. It is 5° W. of the equinoctial colure, and comes to the meridian one hour and forty-one minutes after Regulus, on the 3d of May; when its meridian altitude is the same as the sun's at 12 o'clock the next day.

When Denebola is on the meridian, Regulus is seen 25° W. of it, and Dhad, in the square of Ursa Major, bears 39° N. of it. It forms, with these two, a large right angled triangle; the right angle being at Denebola. It is so nearly on the same meridian with Dhad that it culminates only four minutes before it.

Denebola is 35½° W. of Arcturus, and about the same distance N. W. of Spica Virginis, and forms, with them, a large equilateral triangle on the S. E. It also forms with Arcturus and Cor Caroli a similar figure, nearly as large on the N. E. These two triangles, being joined at their base, constitute a perfect geometrical figure of the form of a Rhombus: called by some, the DIAMOND OF VIRGO.

A line drawn from Denebola through Regulus, and continued 7° or 8° farther in the same direction, will point out ξ and ο, of the 4th and 5th magnitudes, situated in the fore claws, and about 3° apart.

TELESCOPIC OBJECTS.

ω LEONIS.—A. R. = 9 h. 19 m. 53 s. Dec. = + 9° 45′ 0″. A very close double star on the Lion's left fore foot. This has long been a most difficult test object.

Discovered by Herschel, in 1782, who found the pos. = 110° 54′, and estimated the distance at one quarter the diameter of the larger star; whose magnitude is 6½, the smaller 7⅓.

Pos.	153° 56′	Dist.	0″.970	Epoch 1825.21	Strüve.
	178 18		0 .300	1835.33	Strüve.
	194 00		0 .300	1841.35	Mädler.

In 1842 it was seen as a single star, by Mädler.

The elements of the orbit have been computed by Mädler, who finds a period of 82½ years. By his computations the stars were distant 1″.45, their maxium, in 1800. After a lapse of fifty-two years they will reach their least distance 0″.2, which will scarcely be measurable in the most powerful instruments.

57 HERSCHEL I, LEONIS.—A. R. = 9 h. 23 m. 07 s. Dec. = + 22° 12′ 1″. A double white nebula in the lower jaw of Leo. There is a double nucleus with the nebulosities commingling.

γ LEONIS.—A. R. = 10 h. 11 m. 08 s. Dec. = + 20° 39′ 0″. A beautiful double star near the Lion's mane. A 2, bright orange; B 4, greenish yellow. This is doubtless a binary system, whose period may reach a *thousand years!* I have repeatedly examined this splendid object, with a power of 500; the Cincinnati refractor shows the disks of both the stars round and clear.

Discovered by Herschel, 1782.

Pos. 103° 22′ Dist. 2″.50 Epoch 1831.51 Strüve.

67 P. X, LEONIS.—A. R. = 10 h. 17 m. 09 s. Dec. = + 9° 35 2″. A neat double star on the Lion's right shoulder. A 8, B 9½, magnitude. The measures indicate fixity in the components.

Discovered by Herschel.

Pos. 63° 28′	Dist. 4″.00	Epoch 1782.13	Herschel.
65 54	3 .20	1832.56	Strüve.

49 LEONIS.—A. R. = 10 h. 26 m. 38 s. Dec. + 9° 28′ 5″. A close double star under the right shoulder of Leo. A 6, white; B 9, pale blue.

Discovered by Strüve.

Pos. 161° 09′	Dist. 2″.37	Epoch 1830.76	Strüve.
158 01	2 .50	1838.37	Smyth.

95 MESSIER, LEONIS.—A. R. = 10 h. 35 m. 31 s. Dec. = 12° 31′ 09″. A white nebula on the ribs of Leo.

Discovered by Mechain, 1771. One degree east, and following this nebula, is another, less bright, also discovered by Mechain.

18 HERSCHEL I, LEONIS—A. R. = 10 h. 39 m. 49 s. Dec. = 13° 28′ 0″. A pair of bright class nebulæ, with a third faint one in company, on the belly of Leo. This region of the heavens is filled with nebulous clouds, a part of the great stream which encircles the entire heavens.

Discovered by Herschel in 1783.

54 LEONIS.—A. R. = 10 h. 46 m. 56 s. Dec. = + 25° 36′ 01′. A double star over Leo's back. A 4½, B 7.

Discovered by Sir W. Herschel, 1781.

Pos. 102° 48′ Dist. 6″.18 Epoch 1830.35 Strüve.

229 P. X, LEONIS.—A. R. = 10 h. 55 m. 44 s. Dec. = + 4° 30′. A close double star preceding the Lion's hind legs. A 8, B 8, magnitude.

Discovered by Strüve, and by him measured as follows:

Pos. 275° 48′ Dist. 1″.076 Epoch 1829.13

13 HERSCHEL I, LEONIS.—A. R. = 10 h. 57 m. 37 s. Dec. = 0° 49′ 6″. A bright nebula preceding the Lion's hind feet. Discovered by Herschel, and one of a vast number of similar objects in this region. Near this object Sir William examined more than 150 square degrees of diffused nebulosity, an extent so vast as to defy the powers of arithmetic to compute its dimensions. If we abandon the theory of the existence of chaotic nebulous matter, and regard all these multitudinous stains of light as consisting of myriads of suns, the extent of these "island universes" here located, is almost infinitely greater than all that the human eye can grasp on the brightest night. Herschel expresses himself thus, "The high degree of rarefaction of nebulous matter, should not be considered an obstacle to the theory of its finally being condensed into a body of the density of the sun; for supposing the nebula distant 320 billions of miles, and its diameter equal to 10′, then must its magnitude exceed that of the sun more than two trillions of times!"

What then must be the extent of a group of objects covering 150 square degrees, and so remote that their millions of aggregated suns produce but a barely perceptible stain of light on the deep blue ground of the heavens ?

239 P. X, Leonis.—A. R. = 10 h. 58 m. 17 s. Dec. = + 7° 59′ 09″. A double star close to the Lion's hind legs. A 8, B $11\frac{1}{2}$, magnitude. It is probably fixed in position.
Pos. 164° 46′ Dist. = 8″.03 Epoch 1833.28 Strüve.

9. P. XI, Leonis.—A. R. = 11 h. 05 m. 17 s. Dec. = + 21° 00′ 03″. A neat double star on Leo's loins. A $7\frac{1}{2}$, B $7\frac{1}{2}$, magnitude.
Discovered by Strüve.
Pos. 287° 48′ Dist. 1″.052 Epoch 1829.70 Strüve.

66 Messier, Leonis.—A. R. = 11 h. 11 m. 48 s. Dec. = + 13° 52′ 04″. A large elongated nebula with a bright nucleus, preceded by another of a similar shape.
Discovered by Michain, 1780, and registered No. 66 and 65 Messier. A third nebula follows on the same parallel, 174 seconds of time.

ι Leonis.—A. R. = 11 h. 15 m. 35 s. Dec. = + 11° 24′ 08″. A binary star on the Lion's flank, 7° south-west of Denebola. A 4, pale yellow ; B $7\frac{1}{2}$, light blue.
Discovered by Strüve

Pos. 97° 00′	Dist. 2″.30	Epoch 1827.28	
86 00	2 .50	1842.38	Smyth.

Other nebulæ and double stars will be found on the star maps.

SEXTANS.

The Sextant, called also Urania's Sextant, is a modern constellation that Hevelius made out of the unformed stars of the ancients, which lay scattered between the Lion, on the N., and Hydra, on the S.

It contains forty-one very small stars, including only one as large as the 4th magnitude. This is situated very near the equinoctial, 13° S. of Regulus, and comes to the meridian about the same time on the 6th of April. The other stars in this constellation are too small to engage attention. A few of the largest of them may be traced out from the map.

TELESCOPIC OBJECTS.

161 P. IX, Sextantis.—A. R. = 9 h. 35 m. 09 s. Dec. = 3° 21′ 04″. A double star on the old Lion's leg, but included in the new constellation, the Sextant. A 8, "yellowish white;" B 13, "blue."

Pos.	145° 00′	Dist. 4″.00	Epoch 1834.26	Smyth.
	142 20	3 .317	1830.24	Strüve.

163 Herschel I, Sextantis.—A. R. = 9 h. 57 m. 16 s. Dec. = — 6° 56′ 09″. An elongated bright nebula, on the limb of the Sextant. Discovered by Herschel, 1787.

4 Herschel I, Sextantis.—A. R. = 10 h. 05 m. 58 s. Dec. = + 4° 15′ 01″. A bright round nebula on the frame of the Sextant, followed by another at the distance of twenty-nine seconds of time.

Discovered by Herschel, 1783; who, however, overlooked the following one, which was subsequently discovered by his son.

35 Sextantis.—A. R. = 10 h. 35 m. 02 s. Dec. = + 5° 35′ 02″. A double star on the north extreme of the limb. A 7, B 8.

Pos. 240° 47′ Dist. 6″.75 Epoch 1825.20 Strüve.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. X.

Hydra—The Water Serpent.
Pocula—The Cup.
Felis—The Cat.
The Compass.

Favorably situated for examination in March, April and May.

HYDRA AND THE CUP.

Hydra, the Water Serpent, is an extensive constellation, winding from E. to W. in a serpentine direction, over a space of more than one hundred degrees in length. It lies south of Cancer, Leo, and Virgo, and reaches almost from Canis Minor to Libra. It contains sixty stars, including one of the 2d magnitude, three of the 3d, and twelve of the 4th.

Alphard, or *Cor Hydræ*, marked α, in the heart, is a lone star of the 2d magnitude, 23° S. S. W. of Regulus, and comes to the meridian at the same time with λ, in the point of the sickle, about twenty minutes before 9 o'clock on the 1st of April. There is no other considerable star near it, for which it can be mistaken. An imaginary line drawn from γ Leonis through Regulus, will point out Cor Hydræ, at the distance of 23°.

The head of Hydra may be distinguished by means of four stars of the 4th magnitude, 2½° and 4° apart, and forming a rhomboidal figure. The three upper stars in this cluster form a small arch, and may be known by two very small stars just below the middle one, making with it a very small triangle. The three western stars in the head, also make a beautiful little triangle. The easten star in this group, marked ζ, is about 6° directly S. of Acubens, and culminates at the same time.

When Alphard is on the meridian, *Alkes*, marked α, of the 4th magnitude, situated in the bottom of the Cup, may be seen 24° S. E. of it, and is distinguished by its forming an equilateral triangle with β and γ, stars of the same magnitude, 6° S. and E. of it. Alkes is common both to Hydra and the Cup. β, on the S., is in Hydra, and γ, on the N. E., is near the middle of the Cup. A line drawn from Zozma, through ϑ Leonis, and continued 38½° directly S. will reach β; it is therefore on the same meridian, and will culminate at the same time on the 23d of April.

The Cup itself, called also the *Crater*, may be easily distinguished by means of six stars of the 4th magnitude, forming a beautiful crescent, or semicircle, opening to the W. The center of this group is about 15° below the equinoctial, and directly S.

of the hinder feet of Leo. The crescent form of the stars in the Cup is so striking and well defined, when the moon is absent, that no other description is necessary to point them out. Its center comes to the meridian about two hours after Alphard, on the same evening; and consequently, it culminates at 9 o'clock, one month after Alphard does. The remainder of the stars in this constellation may be easily traced by aid of the map.

When the head of Hydra is on the meridian, its other extremity is many degrees below the horizon, so that its whole length cannot be traced out in the heavens until its center, or the Cup, is on the meridian.

——" Near the equator rolls
The sparkling Hydra, proudly eminent
To drink the *Galaxy's* refulgent sea;
Nearly a fourth of the encirling curve
Which girds the ecliptic, his vast folds involve;
Yet *ten* the number of his stars diffused
O'er the long track of his enormous spires:
Chief beams his heart, sure of the second rank,
But emulous to gain the first."—*Eudosia.*

TELESCOPIC OBJECTS.

108 P. VIII, Hydræ.—A. R. = 8 h. 27 m. 20 s. Dec. = + 7° 10′ 05″. A double star between the head of Hydra and Cancer. A 6, "pale yellow;" B 7½, "rose tint."
Discovered by Herschel.
Pos. 25° 45′ Dist. 10″.33 Epoch 1832.95 Strüve.

17 Hydræ.—A. R. = 8 h. 47 m. 39 s. Dec. = — 7° 21′ 08″. A close double star between the Unicorn's tail and Hydra's heart. A and B 7 magnitude.
Discovered by Herschel.
Pos. 358° 50′ Dist. 4″.33 Epoch 1831.59 Strüve.

27 Herschel IV, Hydræ.—A. R. = 10 h. 17 m. 01 s. Dec. = — 17° 50′ 06″. A planetary nebula in the middle of Hydra's body.
Discovered by Herschel, 1785.

α Crateris.—A. R. = 10 h. 52 m. 00 s. Dec. = — 17° 26′ 09″. A star with two distant companions on the base of the Cup. These are remarkable for their color. A 4, orange; B 8, blood red; C 9, pale blue.
Difference between A and B 42″.1
" " A and C 4 .9

39 P. XI, Crateris.—A. R. = 11 h. 11 m. 38 s. Dec. = — 06° 01′ 04″. A small double star between the Cup and the Lion's hind feet. A 8½, B 9, magnitude.
Discovered by Strüve.
Pos. 314° 06′ Dist. 7″.65 Epoch 1830.23 Strüve.

γ Crateris.—A. R. = 11 h. 16 m. 54 s. Dec. = — 16° 48′ 03″. A close double star in the center of the goblet. A 4, B 14, magnitude.
Discovered by Herschel.
Pos. 102° 05′ Dist. 3″.00 Epoch 1838.26 Smyth.

17 Crateris.—A. R. = 11 h. 24 m. 21 s. Dec. = — 28° 23′ 00″. A double star in the boundary of the Cup. A 5½, B 7, magnitude.
Discovered by Herschel, 1783.
Pos. 207° 08′ Dist. 10″.01 Epoch 1833.21 Smyth.

CHAPTER III.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. XI.

VIRGO—THE VIRGIN.
CORVUS—THE CROW.

Favorably situated for examination in April, May and June.

VIRGO.

THE VIRGIN.—This is the sixth sign, and seventh constellation in the ecliptic. It is situated next east of Leo, and about midway between Coma Berenices on the N. and Corvus on the S. It occupies a considerable space in the heavens, and contains, according to Flamsted, one hundred and ten stars, including one of the 1st, six of the 3d, and ten of the 4th magnitudes. Its mean declination is 5° N., and its mean right ascension is 195°. Its center is therefore on the meridian about the 23d of May.

The sun enters the *sign* Virgo, on the 23d of August, but does not enter the *constellation* before the 15th of September. When the sun is in this sign, the earth is in Pisces; and vice versa.

Spica Virginis, marked α, in the ear of corn which the Virgin holds in her left hand, is the most brilliant star in this constellation, and situated nearly 15° E. N. E. of Algorab, marked α, in the Crow, about 35° S. E. of Denebola, and nearly as far S. S. W. of Arcturus—three very brilliant stars of the 1st magnitude, that form a large equilateral triangle, pointing to the S. Arcturus and Denebola, marked β, are also the base of a similar triangle on the north, terminating in Cor Caroli, which, joined to the former, constitutes the *Diamond of Virgo.* The length of this figure, from Cor Caroli on the north, to Spica Virginis on the south, is 50°. Its breadth, or shorter diameter, extending from Arcturus on the east, to Denebola on the west, is 35½°. Spica may otherwise be known by its solitary splendor, there being no visible star near it, except one of the 5th magnitude, situated about 1° below it, on the left.

The position of this star in the heavens, has been determined with great exactness for the benefit of navigators. It is one of the stars from which the moon's distance is taken for determining the longitude at sea. Its situation is highly favorable for this purpose, as it lies within the moon's path, and little more than 2° below the earth's orbit.

Its right ascension being 199°, it will come to our meridian at 9 o'clock about the 28th of May, in that point of the heavens where the sun is at noon about the 20th of October.

Vindemiatrix, marked ε, is a star of the 3d magnitude, in the right arm, or northern wing of Virgo. and is situated nearly in a straight line with, and midway between Coma Berenices, and Spica Virginis. It is 19½° S. W. of Arcturus, and about the same distance S. E. of Coma Berenices, and forms with these two a large triangle, pointing to the south. It bears also 18° S. S. E. of Denebola, and comes to the meridian about twenty-three minutes before Spica Virginis.

Zeta, is a star of the 3d magnitude, 11½° N. of Spica, and very near the equinoctial. *Gamma*, situated near the left side, is also a star of the 3d magnitude, and very near the equinoctial. It is 13° due west of ζ, with which and Spica it forms a handsome triangle. *Eta*, is a star of the 3d magnitude, in the southern wing, 5° W. of γ, and but 2½° E. of the autumnal equinox.

Beta, called also *Zavijava*, is a star of the 3d magnitude, in the shoulder of the wing, 7⅓° W. of η, with which and γ, it forms a line near the earth's orbit, and parallel to it. β, η, γ and Spica, form the lower and longer side of a large spherical triangle, whose vertex is in β. The other stars in this figure may be easily traced by means of the map. About 13° E. of Spica, there are two stars of the 4th magnitude, 3° apart, which mark the foot of Virgo. These two stars are on nearly the same meridian with

Arcturus, and culminate nearly at the same time. The lower one marked *Lambda*, is on the south, and but 8° W. of the principal star in Libra. Several other stars of the 3d magnitude lie scattered about in this constellation, and may be traced out by the map.

> "Her lovely tresses glow with starry light;
> Stars ornament the bracelet on her hand;
> Her vest in ample fold, glitters with stars:
> Beneath her snowy feet they shine; her eyes
> Lighten, all glorious, with the heavenly rays,
> But *first* the star which crowns the golden sheaf."

History.—The famous zodiac of Dendera, as we have already noticed, commences with the sign Leo; but another zodiac, discovered among the ruins at Estne, in Egypt, commences with Virgo; and from this circumstance, some have argued, that the regular precession of the equinoxes established a date to this at least 2000 years older than that at Dendera. The discoveries of Champollion, however, render it probable that this ancient relic of astrology at Estne was erected during the reign of the Emperor Claudius, and consequently did not precede the one at Dendera more than fourteen years.

Of this, however, we may be certain: the autumnal equinox now corresponds with the first degree of *Virgo;* and, consequently, if we find a zodiac in which the summer solstice was placed where the autumnal equinox now is, that zodiac carries us back 90° on the ecliptic; this divided by the annual precession of 50¼", must fix the date at about 6450 years ago. This computation, according to the chronology of the Sacred writings, carries us back to the earliest ages of the human species on earth, and proves, at least, that astronomy was among the first studies of mankind. The most rational way of accounting for this zodiac, says Jamieson, is to ascribe it to the family of Noah; or perhaps to the patriarch himself, who constructed it for the benefit of those who should live after the deluge, and who preserved it as a monument to perpetuate the actual state of the heavens immediately subsequent to the creation.

TELESCOPIC OBJECTS.

A Nebula.—A. R. = 12 h. 06 m. 01 s. Dec. = + 15° 47′ 02″. This nebula is situated between Virgo's right wing and Leo's tail.

Discovered by Messier, 1781, and described by him as "a nebula without a star, with an extremely faint light.

A Long Pale-White Nebula.—A. R. = 12 h. 07 m. 37 s. Dec. + 14° 02′ 08″. On the upper part of Virgo's left wing. Described in the Bedford Catalogue as "a very curious object, resembling a weaver's shuttle, and lying across the parallel. The upper branch is the faintest, and exhibits a palpable nucleus."

Discovered by Herschel, 1783.

A Large Nebula.—A. R. = 12 h. 13 m. 45 s. Dec. = + 05°

21′ 06″. This nebula is situated between the Virgin's shoulders. Herschel reports it to have two neuclei about 90″ apart.
Discovered by Messier, 1799.

17 Virginis.—A. R. = 12 h. 14 m. 24 s. Dec. = 06° 11′ 08″. A double star between the shoulders of Virgo. A 6, B 9, magnitude.
Pos. 336° 45′ Dist. 19″.32 Epoch 1829.26 Struve.
The components appear to be stationary.

A Round Nebula.—A. R. = 12 h. 14 m. 52 s. Dec. = + 16° 42′ 06″. It appears off the upper part of the Virgin's left wing.
Discovered by Mechain, 1781.
It is one of a multitude of nebulous masses forming a wonderful zone, and passing round the heavens in a direction nearly perpendicular to the Milky Way. The discovery of this great stratum, is the result of the unwearied zeal and perseverance of Sir William Herschel.

A Bright Nebula.—A. R. = 12 h. 21 m. 36 s. Dec. + 08° 52′ 09″. This nebula is situated on Virgo's left shoulder.
Discovered by Orioni, 1771.

A Long Elliptical Nebula.—A. R. = 12 h. 23 m. 54 s. Dec. = + 15° 18′ 05″. It appears on the outer side of Virgo's left wing. In a zone three degrees square a large number of nebulæ are found, whose relative positions are exhibited in the diagram marked nebulæ in Virgo.

γ Virginis.—A. R. = 12 h. 33 m. 33 s. Dec. = — 00° 34′ 03″. A remarkable binary star, on the Virgin's right side. A 4, B 4, magnitude. In consequence of some very early observations, by Bradly, Pound, Cassini, and Mayer, it was thought that this star presented an admirable opportunity of testing the influence of gravitation among these remote objects. As early as 1718, the positions of the components seem to have been approximately obtained. Measures were again made in 1720, 1756, and by Sir W. Herschel in 1780. These. combined with modern observations, furnished the data for the computation of the elements of the orbits, described by these two suns about their common center of gravity. From the earliest period of observation, the distance between the two stars composing γ Virginis, had been on the decrease, while the angular velocity was rapidly increasing; following, in this respect, the analogy of the planets and comets, whose angular velocity rapidly increases as their distance from the sun decreases. Sir John Herschel made the first effort at a determination of the elements of the orbit, and found a period of 513.28 years by the first computed elements, and of 628.90 years by the second set of elements. These results were greatly in error. owing to the fact, as Sir John Herschel says, to the use of Bradly's observations of 1718. In the meantime M. Mädler, of Dorpat, had shown that the periodic time could not well exceed 157 years, a result finally reached by Herschel himself.

After much laborious calculation, M. Mädler reached the conclusion that the perihelion or pereaster passage occurred 1836.31, and that the periodic time was 145.409 years. With his last set of elements, he has computed an ephemeris of this system, from which we copy as follows:

Pos. 359° 53′ 06″	Dist. 02″.417	Epoch	1847
357 43 04	02 .556		1848
355 55 06	02 .689		1849
354 13 03	02 .816		1850
352 39 06	02 .939		1851
351 13 06	03 .057		1852
349 53 05	03 .170		1853

During a part of the year 1836, the star was seen perfectly round, even in the most powerful instruments. Objects which had been so widely separated, when first discovered, were now so placed as that the one *eclipsed the other*. Towards the close of 1836, the hidden star began to emerge, and this double object was seen *elongated*. At the beginning of 1837, the best telescopes again saw the *two stars* separate and distinct. From that time, to the present, the distance has been on the increase, while the angular velocity has been regularly diminishing. My own observations show the ephemeris computed by Mädler, to be pretty accurate, but even yet considerable discordance exists between observation and computation, showing that more accurate data are yet wanted to complete this most delicate and difficult investigation

A few measures are here given.

Pos. = 319° 07′	Dist. 07″.49	Epoch 1720.31	Cassini.
310 04	- - -	1781.89	Herschel I.
285 04	02 .86	1822.00	Strüve.
262 10	01 .58	1830.59	Bessel.
245 32	01 .05	1833.37	Strüve.
077 55	00 .58	1837.41	Strüve.
020 11	01 .73	1841.44	Mädler.
011 06	01 .90	1843.33	Smyth.
357 28	03 .09	1847.60	Mitchel.

By a comparison of the last observations with the ephemeris, it will be seen that the angular velocity is greater than predicted, as is also the increase of distance between the components.

θ Virginis.—A. R. = 13 h. 01 m. 40 s. Dec. = — 04° 41′ 00″. A coarse triple star on the lower part of the Virgin's southern wing. A 4½, B 9, C 10, magnitude.

Pos. A B 344° 02′	Dist. 07″.02	Epoch 1837.07	Smyth.
A C 295 00	65 .00	1831.15	

A Close Binary Star.—A. R. = 13 h. 26 m. 07 s. Dec. = + 00° 30′ 04″. This star is situated on Virgo's lower garment. A 8, B 9, magnitude.

Discovered by Strüve, 1825.

Pos. 10° 00′	Dist. 01″.600	Epoch 1825.37	Strüve.
24 08	01 .590	1834.38	Strüve.
36 02	01 .747	1841.37	Mädler.

The period of revolution is, probably, not far from 230 years.

81 Virginis.—A. R. = 13 h. 29 m. 13 s. Dec. = — 07° 03′ 02″.

A close double star on the right side of the lower garment of the Virgin. Suspected of slow retrogradation.

Pos. 41° 07′ Dist. 02″.82 Epoch 1841.39 Mädler.

84 Virginis.—A. R. = 13 h. 35 m 02 s. Dec. = + 04° 21′ 00″. A close double star on the tip of Virgo's left wing. A 6, B 9, magnitude.

Pos. 233° 04′	Dist. 03″.5	Epoch 1839.37	Smyth.
231 05	03 .48	1847.06	Mitchel.

φ Virginis.—A. R. = 14 h. 19 m. 58 s. Dec. = — 01° 30′ 04″. A delicate double star in the corner of Virgo's skirt. A 5, yellow; B 13, blue.

Discovered by Strüve, 1829.

Pos. 108° 32′ Dist. 03″.73 Epoch 1829.74 Strüve.

Other double stars and nebulæ will be found on the chart.

A Double Nebula.—A. R. = 12 h. 35 m. 33 s. Dec. = + 12° 26′ 01″. This nebula is situated in the center of Virgo's left wing, with two or three smaller ones in the immediate vincinity. In this object we find some support to the celebrated nebular theory, which supposes the sun and stars to have been formed from the condensation of nebulous fluids. The object before us suggests the chaotic state of a binary star, and possibly these two shadowy objects are performing, even now, a revolution round each other. Abandoning this theory, and having recourse to the idea that these dim stains are mighty universes of shining stars, here we have two such so located as possibly to be mutually operating upon each other. Should actual physical connection exist, and one of these mighty systems be actually sweeping round the other, what a stupendous period must mark the cycle of these "island universes." By such periods we might even reckon the hours of eternity itself!"

CORVUS.

The Crow.—This small constellation is situated on the eastern part of Hydra, 15° E. of the Cup, and is on the same meridian with Coma Berenices, but as far S. of the equinoctial as Coma Berenices is N. of it. It therefore culminates at the same time, on the 12th of May. It contains nine visible stars, including three of the 3d magnitude, and two of the 4th.

This constellation is readily distinguished by means of three stars of the 3d magnitude, and one of the 4th, forming a trapezium or irregular square, the two upper ones being about 3½° apart, and the two lower ones 6° apart.

The brightest of the two upper stars, on the left, is called *Algorab*, marked α, and is situated in the E. wing of the Crow; it has nearly the same declination S. that the Dog-star has, and is on the meridian about the 13th of May. It is 21½° E. of Alkes in the Cup, 14½° S. W. of Spica Virginis, a brilliant star of the 1st magnitude, to be described in the next chapter.

Beta, on the back of Hydra and in the foot of the Crow is a star of the 3d magnitude, nearly 7° S. of Algorab. It is the brightest of the two lower stars, and on the left. The right hand lower one is a star of the 4th magnitude, situated in the neck, marked *Epsilon*, about 6° W. of β, and may be known by a star of the same magnitude situated 2° below it, in the eye, and called *Al Chiba*. ε is 21⅔° S. of the vernal equinox, and if a meridian should be drawn from the pole through Megrez, and produced to ε Corvi, it would mark the equinoctial colure.

Gamma in the W. wing, is a star of the 3d magnitude, 3½° W. of Algorab, and is the upper right hand one in the square. It is but 1° E. of the equinoctial colure.

10° E. of β is a star of the 3d magnitude, in the tail of Hydra, marked γ; these two, with Algorab, form nearly a right angled triangle, the right angle being at β.

TELESCOPIC OBJECTS.

δ Corvi.—A. R. = 12 h. 21 m. 35 s. Dec. = — 15° 34′ 04″. A fine double star on the Raven's right wing. A 3, B 8½ magnitude. Discovered by Herschel, 1782.

Pos. 210° 54′ Dist. 23″.5 Epoch 1831.34 Smyth.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. XII.

URSA MAJOR—THE GREAT BEAR.

Favorably situated for examination in May, June. July, August and September.

URSA MAJOR.

THE GREAT BEAR.—This great constellation is situated between Ursa Minor on the north, and Leo Minor on the south. It is one of the most noted and conspicuous in the northern hemisphere. It has been an object of universal observation in all ages of the world. The priests of Belus, and the Magi of Persia; the shepherds of Chaldea, and the Phœnician navigators, seem to have been equally struck with its peculiar outlines. And it is somewhat remarkable that a remote nation of American aborigines, the Iroquois, and the earliest Arabs of Asia, should have given to the very same constellation the name of "Great Bear," when there had probably never been any communication between them; and when the name itself is so perfectly arbitrary, there being no resemblance whatever to a bear, or to any other animal.

It is readily distinguished from all others by means of a remarkable cluster of seven bright stars, forming what is familiarly termed the *Dipper*, or *Ladle*. In some parts of England it is called "Charles's Wain," or wagon, from its fancied resemblance to a wagon drawn by three horses in a line. Others call it the *Plow*. The cluster, however, is more frequently put for the whole constellation, and called, simply, the Great Bear. But we see no reason to reject the very appropriate appellation of the shepherds, for the resemblance is certainly in favor of the Dipper: the four stars in the square forming the bowl, and the other three, the handle.

When the Dipper is on the meridian, above the pole, the bottom lies towards us, with the handle on the right.

Benetnasch, marked η, is a bright star of the 2d magnitude, and is the first in the handle. The second, or middle star in the handle, is *Mizar*, marked ζ, 7° distant from Benetnasch. It may be known by means of a very minute star almost touching it, called *Alcor*, which appears to be double when seen through a telescope, and of a silver white. The third star in the handle is called *Alioth*, marked ϵ, and is about 4½° W. of Mizar. Alioth is very nearly opposite Shedir in Cassiopeia, and at an equal distance from the pole. Benetnasch, Mizar, and Alioth, constitute the handle, while the next four in the square form the bowl of the Dipper.

Five and a half degrees W. of Alioth is the first star in the *top* of the Dipper, at the junction of the handle, called *Megrez*, and marked δ; it is the smallest and middle one of the cluster, and is used in various observations both on sea and land, for important purposes. At the distance of 4½° S. W. of Megrez, is Phad, marked γ, the first star in that part of the bottom, which is next the handle.

The stars in this cluster are so well known, and may be so easily described without reference to their relative bearings, that they would rather confuse than assist the student, were they given with ever so much accuracy. The several bearings for this cluster were taken when Megrez was on the meridian, and will not apply at any other time, though their respective distances will remain the same.

At the distance of 8° W. of Phad, is the westernmost star in the bottom of the Dipper, called *Merak*, marked β. The bright star 5° N. of it, towards the pole is called *Dubhe*, and marked α; but these two, Merak and Dubhe, are, by common consent, called the *Pointers*, because they always point towards the pole; for, let the line which joins them be continued in the same direction $28\frac{3}{4}°$ farther, it will just reach the north pole.

The names, positions, and relative distances of the stars in this cluster, should be well remembered, as they will be frequently adverted to. The distance of Dubhe, or the Pointer nearest to the north pole, is $28\frac{3}{4}°$. The distance between the two upper stars in the Dipper is 10°; between the two lower ones 8°: the distance from the brim to the bottom next the handle, is $4\frac{1}{2}°$; between Megrez and Alioth is $5\frac{1}{2}°$; between Alioth and Mizar $4\frac{1}{2}°$, and between Mizar and Benetnasch, 7°.

The reason why it is important to have these distances clearly settled in the mind is, that these stars, being always in view, and more familiar than any other, the student will never fail to have a standard measure before him, which the eye can easily make use of in determining the distances between other stars.

The position of Megrez in Ursa Major, and of Caph in Cassiopeia, is somewhat remarkable. They are both in the equinoctial colure, almost exactly opposite each other, and equally distant from the pole. Caph is in the colure, which passes through the vernal equinox, and Megrez is in that which passes through the autumnal equinox. The latter passes the meridian at 9 o'clock, on the 10th of May, and the former just six months afterwards, at the same hour, on the 10th of November.

Psi, in the left leg of Ursa Major, is a star of the 3d magnitude, in a straight line with Megrez and Phad, distant from the later $12\frac{1}{2}°$. A little out of the same line, 3° farther, is another star of the 5th magnitude, marked *Omega*, which may be distinguished from ψ, from its forming a straight line with the two *Pointers*.

The right fore paw, and hinder one, are distinguished by two stars of the 4th magnitude, between 1° and 2° apart. The two stars of the left hind paw are of the 3d magnitude. These three duplicate stars are nearly in a right line, 20° S. of, and in a direction nearly parallel with, Phad and Dubhe, and are the only stars in this constellation that ever set in this latitude.

There are few other stars of equal brightness with those just described, but amidst the more splendid and interesting group with which they are clustered, they seldom engage our observation.

The whole number of visible stars in this constellation is eighty-seven; of which six are of the 2d, three of the 3d, and about twice as many of the 4th magnitude.

TELESCOPIC OBJECTS.

286 H. I, Ursæ Majoris.—A. R. = 09 h. 49 m. 30 s. Dec. + 69° 30′. A round nebula, thus described in the Bedford Catalogue. "A bright class round nebula at the back of Ursa Major's left ear. It is lucid white, and lights up at the center. There are two lines, of three stars each, across the field, of which the one preceding the nebula is of the 7th magnitude, and that following of the 10th; between these the sky is intensely black, and shows the nebula as if floating in awful and illimitable space at an inconceivable distance. Dr. Derham, whose judgment led him to consider nebulæ as vast areas of light, "infallibly beyond the fixed stars," thought that some of them might be openings in the opacity surrounding the visible system, which chasms show us the light of the empyreal sphere beyond it.

"Discovered by Sir W. Herschel in November 1801, and he says that 'on the north following side there is a faint ray interrupting the roundness.'"

I have recently examined this object with care, but it had sunk too low to be well seen. It appeared fainter than any of those whose descriptions follow, and smaller. It occupies an insignificant portion of the field of view, and in case we receive it as a distinct globular cluster, an "island universe," its distance must be enormous.

47 M. Ursæ Majoris.—A. R. = 11 h. 05 m. 24 s. Dec. = + 55° 52′ 09″. Is thus described in the Bedford Catalogue. "A large planetary nebula or globular collection of nebulous matter, on the Great Bear's flank, with several stars in the field, one of which is pretty close. It lies about 2° south-east of Merak, just south of the line joining Merak and Phad. This very singular object is circular and uniform, and after

a long inspection looks like a condensed mass of attenuated light, seemingly of the size of Jupiter. Sir W. Herschel remarks: 'From the observations of the twenty feet telescope, it appears that the profundity of this object is beyond the guaging power of that instrument; and as it must be sufficiently distant to be ambiguous it cannot be less than that of the 980th order'—or 980 times more remote than Sirius."

Discovered by Messier in 1781.

43 H. V, Ursæ Majoris.—A. R. = 12 h. 11 m. 04 s. Dec. = + 48° 11′. This object was examined by myself on the evening of the 2d July, 1847, when the following memoranda were made:

Magnifying power 260. The nebula is elongated north and south, stretching nearly across the field of view. A faint star was seen near each extremity. The nebulosity very faint on the right, gradually fading away at each extremity. The nucleus resembles a small star elongated so as to cross the longer axis of the nebula at angle of about 30°.

Power 500.

The nebula undergoes but little change. The nucleus less perfectly defined than with the lower power.

This object may be found by drawing a line from α through γ Ursa Majoris, and extending it about 7½° beyond the last named star. Although large, it is faint, and requires a large aperture to give it much interest. In case it be a universe of fixed stars, its distance must be beyond the stretch of imagination, and the clustering of worlds at its center must be far greater than in any other part of its vast extent. It may be an immense annulus, or ring, seen obliquely; and, possibly, resembles somewhat our own sidereal stratum in figure.

195 H. I, Ursæ Majoris.—A. R. = 11 h. 58 m. 51 s. Dec. = + 43° 57′ 03″. Described in the Bedford catalogue as a bright class nebula. My own notes are in the following language: A small, elongated nebula, running nearly north and south. The length is four or five times the breadth. The nucleus is quite sharp. The entire length does not appear to exceed 30″ or 40″. It is preceded by a coarse double star. Examined with a power of 260, and an aperture of 12 inches.

Discovered by Sir William Herschel, 1778. Its shape is not unlike the preceding nebula, but its brightness is much greater. It requires a good instrument to bring it fairly to view.

194 H. I, Ursæ Majoris.—A. R. = 11 h. 17 m. 21 s. Dec. = + 44° 27′ 09″. This object was examined by myself in July, 1847. It is a faint nebula, elongated from north to south. There is a telescopic star on the right, equal in brightness to the nucleus of the nebula. It is followed by three telescopic stars, forming a flat isosceles triangle, whose vertex points to the nebula. Its length is about 50″. A ray from Regulus to γ Ursæ Majoris, reaches the nebula at about two-thirds the distance between the stars.

46 H. V, Ursæ Majoris.—R. A. = 11 h. 02 m. 02 s. Dec. = + 56° 31′ 08″. I find the nebula elongated in the direction of the parallel.

With a power of 260, the nebulosity extends half across the field of view. The nucleus is certainly *double*. The smaller point of light is below, and to the right, at a distance of about 10″. No mention is made of the double nucleus by either Herschel, or by any astronomer whose description has met my eye.

δ 2 URSÆ MAJORIS. A. R. = 8 h. 56 m. 13 s. Dec. = + 67° 46′ 07″. A double star, in the Bear's forehead, A 5½, B 9½. The color of the principal star is white, while its companion is blue.

Pos. 283° 00′	Dist. 7″.95	Epoch 1782.42	Herschel.
263 33	4 .59	1832.14	Strüve.

This would indicate orbitual motion; but, owing to the defects in Herschel's early observations, it requires confirmation.

ξ URSÆ MAJORIS.—A. R. = 11 h. 09 m. 38 s. Dec. = + 32° 25′ 08″. A *binary* star, in the Bear's left hind paw, A 4, B 5½, magnitude.

Sir John Herschel finds for this system a period of revolution equal to 59 years. M. Savary gives 58¼ years for its period. In case these results are reliable, a knowledge of the distance of this system would give to us the relative magnitude of the stars, and their mass, compared with our sun.

Pos. 143° 47′	Dist. 3″.50	Epoch 1780.33	Herschel.
229 30	1 .82	1827.26	Strüve.
143 20	2 .30	1843.16	Smyth.

Here is exhibited a complete revolution of the angle of position through 360°, from the epoch of the first observation to that of the last.

ν URSÆ MAJORIS—A. R. = 11 h. 09 m. 49 s. Dec. = + 33° 58′. A double star, on the Bear's left hind foot, A 4, B 12.

Pos. 147° 02′ Dist. 7″.8 Epoch 1834.31

ζ URSÆ MAJORIS MIJAR.—A. R. = 13 h. 17 m. 28 s. Dec. = + 55° 45′ 08″. A beautiful double star, in the middle of the tail of the Bear, A 3, B 5, magnitude.

Pos. 145° 20′	Dist. 14″.24	Epoch 1819.70	Strüve.
147 24	14 .40	1839.32	Smyth.

It is uncertain whether any physical connection exists between the two components, though an identity of proper motion would lead us to think them united. In exhibiting this double star to those not familiar with the heavens, on taking the eye from the telescope, and looking at the star with the unaided vision, many persons exclaim that they see the small star with the naked eye. This is, however, a mistake. The faint star really seen is not the one shown by the telescope, but a much more distant minute star, called *Alcor*. Indeed, with the great refractor of the Cincinnati Observatory, Alcor, which to the eye appears so very close to Mizar, does not even fall within that field of view of the telescope, which is occupied by Mizar in its center.

From the fact that Alcor and Mizar have an identity of proper motion, it has been argued that they may constitute a binary system—two suns revolving around their common center of gravity. Should this be true, and their distance be assumed as great as that assigned to stars of the same magnitude, they cannot complete their revolution in a period less than 190,000 of our years!

In the Memoirs of the Observatory of the Collegio Romano, 1842, some singular notices of Mizar are made, which I venture to translate.

I give the substance of the notices as follows:

On the 18th April, 1841, M. Mädler communicated to M. Arago the singular fact that, at 9 o'clock and 8 minutes, on that evening, he had seen Mizar *without a companion.* About 10 o'clock, the small star reappeared in all its brilliancy. He thinks he had observed the same phenomenon, with an inferior instrument, in 1834, and infers that the small star is variable, with a long period. The Italian astronomers report the detection of four minute points in the same field with Mizar, some or all of which appear to be variable.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. XIII.

BOOTES—THE BEAR DRIVER.
CORONA BOREALIS—THE NORTHERN CROWN.
QUADRANS—THE QUADRANT.
CANES VENATICI—THE GREY HOUNDS.
COMA BERENICES—BERENICES' HAIR.

Favorably situated for examination in May, June and July.

BOOTES.

THE BEAR DRIVER is represented by the figure of a huntsman in a running posture, grasping a club in his right hand, and holding up in his left the leash of his two grey hounds, Asterion and Chara, with which he seems to be pursuing the Great Bear round the pole of the heavens. He is thence called Arctophylax, or the "Bear Driver."

This constellation is situated between Corona Borealis, on the east, and Cor Caroli, or the Greyhounds, on the west. It contains fifty-four stars including one of the 1st magnitude, seven of the 3d, and ten of the 4th. Its mean declination is 20° N., and mean right ascension is 212°; its center is therefore on the meridian the 9th of June.

Boötes may be easily distinguished by the position and splendor of its principal star, *Arcturus*, which shines with a reddish luster, very much resembling that of the planet Mars.

Arcturus, marked α, is a star of the 1st magnitude, situated near the left knee, 26° S. E. of Cor Caroli and Coma Berenices, with which it forms an elongated triangle, whose vertex is at Arcturus.

Five or six degrees S. W. of Arcturus are three stars of the 3d and 4th magnitudes, lying in a curved line, about 2° apart, and a little below the left knee of Boötes; and about 7° E. of Arcturus are three or four other stars of similar magnitude, situated in the other leg, making a larger curve N. and S.

Mirac, marked ε, in the girdle, is a star of the 3d magnitude, 10° N. N. E. of Arcturus, and about 11° W. of Alphacca, or α in the Northern Crown. *Seginus*, marked γ, in the west shoulder, is a star of the 3d magnitude, nearly 20° E. of Cor Caroli, and about the same distance N. of Arcturus, and forms, with these two, a right angled triangle, the right angle being at Seginus.

Alkaturops, marked μ, situated in the top of the club, is a star of the 4th magnitude, about 10½° in an easterly direction from γ, which lies in the left shoulder: and about 4½° S. of Alkaturops is another star of the 4th magnitude, in the club near the east shoulder, marked *Delta* δ is about 9° distant from Mirac, and 7½° from Alphacca, and forms, with these two, a regular triangle.

Nekkar, marked β, is a star of the 3d magnitude, situated in the head, and is about 6° N. E. of Seginus, and 5° W. of Alkaturops; it forms with δ and Seginus, nearly a right angled triangle, the right angle being at Nekkar.

These are the principal stars in this constellation, except the three stars of the 4th magnitude situated in the right hand. These stars may be known, by two of them being close together, and about 5° beyond Benetnasch, the first star in the handle of the Dipper. About 6° E. of Benetnasch is another star of the 4th magnitude, situated in the arm, which forms, with Benetnasch and the three in the hand, an equilateral triangle.

Arcturus is mentioned by name in that beautiful passage in Job, already referred to, where the

Almighty answers "out of the whirlwind," and says:

"Canst thou the sky's benevolence restrain,
And cause the Pleiades to shine in vain?
Or, when Orion sparkles from his sphere,
Thaw the cold seasons and unbind the year?
Bid Mazzaroth his station know,
And teach the bright *Arcturus* where to glow!"
Young's Paraphrase.

TELESCOPIC OBJECTS.

ι Boötis.—A. R. = 14 h. 10 m. 30 s. Dec. = + 52° 06′ 04″. A delicate triple star in the right hand of Boötes. A 4½, B 4½, C 8, magnitude.

Discovered by Strüve.

A B	Pos. 149° 00′	Dist. 00″.3	Epoch 1836.28	Strüve.
A C	33 09	38 .06	1836.28	

A White Round Nebula.—14 h. 11 m. 44 s. Dec. = 37° 14′ 04″

Discovered by Herschel, on 1st May, 1785.

A Neat Double Star.—A. R. = 14 h. 15 m. 31 s. Dec. = + 09° 10′ 07″. Between the left foot of Boötes and Virgo, on a line between Spica, ζ Boötis. A 6, B white, B 7½, blue.

Discovered by Piazzi.

Pos. 186° 03′ Dist. 06″.26 Epoch 1825.40 Strüve.

π Boötis.—A. R. = 14 h. 33 m. 12 s. Dec. = + 17° 06′ 05″. On the left leg. A 3½, B 6, magnitude.

Pos. 99° 03′	Dist. 06″.00	Epoch 1836.51	Smyth.
96 57	08 .28	1847.60	Mitchel.

ζ Boötis.—A. R. = 14 h. 33 m. 31 s. Dec. = + 14° 25′ 01″. A close double star on the left leg of Boötes. A 3½, B 4½.

Discovered by Herschel, 1796.

Pos. 129° 17′	Dist. 05″.190	Epoch 1830.47	Strüve.
128 24	06 .924	1847.62	Mitchel.

This result, after an interval of seventeen years, determines, it would seem, the fixity of the components, though from early observations motion had been suspected.

ε Boötis.—A. R. = 14 h. 38 m. 00 s. Dec. = + 27° 45′ 01″. A fine double star on the left hip of Boötes. A 3, pale orange; B 7, sea green. This is certainly one of the most beautiful among the double stars.

Discovered by Herschel.

Pos. 320° 47′	Dist. 02″.581	Epoch 1831.41	Strüve.
323 38	02 .917	1841.41	Mädler.
320 50	02 .568	1846.66	Mitchel.

ξ Boötis.—A. R. = 14 h. 44 m. 00 s. Dec. = + 19° 46′ 01″. A binary star on the left knee of Boötes. A 3½, orange; B 6½, purple. The orbit was computed by Sir John Herschel in 1833, but with little success. Mädler thinks the periodic time cannot be nearly so short as that obtained by Herschel. It will probably exceed 400 years.

Discovered by Herschel, 1780.

Pos. 334° 10′	Dist. 07″.22	Epoch 1829.46	Strüve.
324 41	07 .09	1841.43	Mädler.
317 44	06 .482	1847.63	Mitchel.

A Small Nebula.—A. R. = 14 h. 53 m. 53 s. Dec. = + 54° 32′ 07″. Between the right hand of Boötes and Draco.

Discovered by Herschel, 1788.

39 Boötis.—A. R. = 14 h. 44 m. 16 s. Dec. = + 49° 22′ 08″. On the right wrist of Boötes. A 5½, B 6½, magnitude.

Pos. 44° 12′	Dist. 03″.71	Epoch 1830.02	Strüve.
37 00	04 .00	1847.60	Mitchel.

These measures show a retrograde motion, as do all the previous ones.

44 Boötis.—A. R. = 14 h. 58 m. 31 s. Dec. = + 48° 16′ 08″. A close double star in the space following the right arm of Boötes. A 5, B 6, magnitude. This star has occasioned no little difficulty, owing to the abrupt changes which have occurred in the relative positions of the components. Mädler thinks Herschel's first observation is wrong by 180 degrees; an error easily committed, considering the near equality of the two stars. On this hypothesis the periodic time may not differ much from sixty or seventy years. A few measures are added.

Pos. 60° 06′	Dist. 02″.00	Epoch 1781.62	Herschel.
228 00	01 .50	1819.43	Strüve.
233 39	02 .55	1829.30	Strüve.
237 02	04 .068	1841.47	Mädler.
238 20	03 .738	1847.62	Mitchel.

μ 2 Boötis.—A. R. = 15 h. 18 m. 28 s. Dec. = + 37° 54′ 07″. A binary star on the tip of the staff of Boötes. A 8, B 8½, magnitude.

The components are preforming their revolution in a retrograde order, and in a period of 300 or 400 years.

These measures will show the rate of motion.

Pos. 357° 14′	Dist.	Epoch 1782.68	Herschel.
327 00	01″.385	1826.77	Strüve.
315 04	01 .060	1836.65	Strüve.
308 43	06 .885	1841.46	Mädler.

DRACO.*

THE DRAGON.—This constellation, which compasses a large circuit in the polar regions by its ample folds and contortions, contains many stars which may be easily traced.

From the head of the monster, which is under the foot of Hercules, there is a complete coil tending eastwardly, about 17° N. of Lyra; thence he winds down northerly about 14° to the second coil, where he reaches almost to the girdle of Cepheus, then he loops down somewhat in the shape of the letter U, and makes a third coil about 15° below the first. From the third coil he holds a westerly course for about 13°, then goes directly down, passing between the head of the Lesser and the tail of the Greater Bear.

This constellation contains eighty stars, including four of the 2d magnitude, seven of the 3d, and twelve of the 4th.

> "The *Dragon* next. winds like a mighty stream;
> Within its ample folds are *eighty* stars,
> Four of the second order. Far he waves
> His ample spires, involving either *Bear*."

The head of the Dragon is readily distinguished by means of four stars, 3°, 4°, and 5° apart, so situated as to form an irregular square; the two upper ones being the brightest, and both of the 2d magnitude. The right hand upper one, called *Etanin*, has been rendered very noted in modern astronomy from its connection with the discovery of a new law in physical science, called the *Aberration of Light.*

The letter name of this star is *Gamma*, or *Gamma Draconis;* and by this appellation it is most frequently called. The other bright star, about 4° from it on the left, is *Rastaben*, marked β.

* See Map XVII for part of Draco.

About 4° W. of β, a small star may, with close attention, be discerned in the nose of the Dragon, which, with the irregular square before mentioned, makes a figure somewhat resembling an Italic *V*, with the point towards the west, and the open part towards the east. The small star in the nose, is called *Er Rakis*, marked μ.

The two small stars 5° or 6° S. of Rastaben are in the left foot of Hercules.

Rastaben is on the meridian nearly at the same moment with Ras Alhague. Etanin, 40° N. of it, is on the meridian about the 4th of August, at the same time with the three western stars in the face of Taurus Poniatowski, or the V. It is situated less than 2° west of the solstitial colure, and is exactly in the zenith of London. Its favorable position has led English astronomers to watch its appearance, for long periods, with the most exact and unwearied scrutiny.

In the year 1725, Mr. Molyneux and Dr. Bradley fitted up a very accurate and costly instrument, in order to discover whether the fixed stars had any sensible parallax, while the earth moved from one extremity of its orbit to the other; or which is the same, to determine whether the nearest fixed stars are situated at such an immense distance from the earth, that any star which is seen this night directly north of us, will, six months hence, when we shall have gone 190 millions of miles to the eastward of the place we are now in, be then seen exactly north of us still, without changing its position so much as the thickness of a spider's web.

These observations were subsequently repeated, with but little intermission, for twenty years, by the most acute observers in Europe, and with telescopes varying from twelve to thirty-six feet in length. In the meantime, Dr. Bradley had the honor of announcing to the world the very nice discovery, that *the motion of light, combined with the progressive motion of the earth in its orbit, causes the heavenly bodies to be seen in a different position from what they would be, if the eye were at rest.* Thus was established the principle of the *Aberration of Light.*

This principle, or law, now that it is ascertained, seems not only very plain, but self evident. For if light be progressive, the position of the telescope, in order to receive the ray, must be different from what it would have been, if light had been instantaneous, or if the earth stood still.

Hence the place to which the telescope is directed, will be different from the true place of the object.

The quantity of this aberration is determined by a simple proposition. The earth describes 59′ 8″ of her orbit in a day = 3548″, and a ray of light comes from the sun to us in 8′ 13″ = 493″ : now twenty-four hours or 86400″ : 493″ : : 3548″ : 22″; which is the change in the star's place, arising from the cause above mentioned.

Of the four stars forming the irregular square in the head, the lower and right hand one is 5½° N. of Etanin. It is called *Grumium*, and is of the 4th magnitude. A few degrees E. of the square, may be seen, with a little care, eight stars of the 5th magnitude, and one of the 4th, which lies 8° E. of Grumium. This group is in the first coil of the Dragon.

The second coil is about 13° below the first, and may be recognised by means of four stars of the 3d and 4th magnitudes, so situated as to form a small square, about half the size of that in the head.

The brightest of them is on the left, and is marked *Delta*. A line drawn from Rastaben through Grumium, and produced about 14°, will point it out. A line drawn from Lyra through Zi Draconis, and produced 10° farther, will point out *Zeta*, a star of the 3d magnitude, situated in the third coil. ζ may otherwise be known, by its being nearly in a line with, and midway between, Etanin and Kochab. From ζ, the remaining stars in this constellation are easily traced.

Eta, *Theta*, and *Asich*, come next; all stars of the 3d magnitude, and at the distance, severally, of 6°, 4° and 5° from ζ. At Asich, the third star from ζ, the tail of the Dragon makes a sudden crook. *Thuban*, *Kappa*, *Giansar*, follow next, and complete the tail.

Thuban, marked α, is a bright star of the 3d magnitude, 11° from Asich, in a line with, and about midway between, Mizar and the southernmost guard in the Little Bear. By nautical men this star is called the *Dragon's Tail*, and is considered of much importance at sea. It is otherwise celebrated as being formerly the *north polar star*. About 2,300 years before the Christian era, Thuban was ten times nearer the true pole of the heavens than Cynosura now is.

Kappa is a star of the 3d magnitude, 10° from Alpha, between Megrez and the pole. Mizar and Megrez, in the tail of the Great Bear, form, with Thuban and κ, in the tail of the Dragon, a large quadrilateral figure, whose longest side is from Megrez to κ.

Giansar, the last star in the tail, is between the 3d and 4th magnitudes, and 5° from κ. The two pointers will also point out Giansar, lying at the distance of little more than 8° from them, and in the direction of the pole.

TELESCOPIC OBJECTS.

An Oval Nebula.—A. R. = 15 h. 02 m. 03 s. Dec. = + 56° 23′. Under the body of Draco.

Discovered by Herschel, 1789. It is faint at the edges.

A Small Round Nebula.—A. R. = 15 h. 35 m. 53 s. Dec. + 59° 52′. In the center of Draco's body.

Discovered by Herschel, 1788.

This object brightens at the center, presenting a nucleus not very perfectly defined. It is followed in the same field by a much larger elongated nebula, which seems to have escaped all preceding observers. It was discovered, 4th July, 1847, by Mrs. Mitchel, while engaged in a critical examination of the above object. It is faint, but certain, and has an oval or elliptical figure.

μ Draconis.—A. R. = 17 h. 02 m. 02 s. Dec. = 54° 41′ 02″. A fine *binary* star, on the tip of Draco's tongue. A 4, B 4½, magnitude.

Discovered by Herschel, 1781. Since which period a retrograde motion has been in progress, as is fully sustained by the reported measures, viz.—

Pos. 232° 22′	Dist. 4″.35	Epoch 1781.73	Herschel.
205 06	3 .23	1832.22	Struve.
190 57	2 .90	1847.70	Mitchel.

ψ 1 Draconis.—A. R. = 17 h. 44 m. 47 s. Dec. + 72° 13′. A double star, in the middle of Draco's back. A 5½, B 6. Both white. This distance is about 31″; the position 15°. No change seems to have taken place. *See Map, No* XVII.

A Double Star.—A. R. = 17 h. 25 m. 07 s. Dec. = + 50° 59′ 09″. Between the right foot of Hercules and Draco's eye. A 8, B 8½, magnitude.

Pos. 265° 28′	Dist. 3″.17	Epoch 1831.29	Struve.
266 20	3 .03	1847.70	Mitchel.

A Planetary Nebula.—A. R. = 17 h. 58 m. 39 s. Dec. 66° 38′. Between the first twist of Draco and his head.

Discovered by Herschel, in 1786.

This singular object is described in the Bedford Catalogue, without any mention of a remarkably bright but small nucleus which occupies its center. This point was detected by myself, July, 1847. When the eye and attention is attentively fixed on the central point, the nebula *fades from the view*, and the moment the attention is withdrawn from the nucleus, and a casual glance is directed to the nebula, the star fades and the nebula brightens up in a most beautiful manner. This curious phenomenon was noticed by many persons in my company. No one can doubt the connection between this nebulous mass and the round central point of light. It is unlike a star, as it is round and clear, with a minute disk and no radiations. I have discovered but one other object like it. Here is the connecting link between planetary nebulæ and nebulous stars; at least, such would be the opinion of those who still adhere to the *nebulous theory*.

This remarkable object, as will be seen from the position, is in the *pole of the ecliptic.*

o Draconis.—A. R. = 18 h. 48 m. 50 s. Dec. = + 59° 11′ 07″. A double star, on Draco's neck. A 5, B 9, magnitude. Mädler thinks the components physically connected, with a period of about 1600 years.

Pos.	00° 00′	Dist. 26″.37	Epoch 1781.68	Herschel.
	346 33	30 .26	1832.50	Strüve.
	344 51	32 .10	1841.48	Mädler.

ε Draconis.—A. R. = 19 h. 48 m. 41 s. Dec. 69° 51′ 06″. In the bend of Draco's back. A $5\frac{1}{2}$, B $9\frac{1}{2}$, magnitude.

Discovered by Herschel, whose first measures are probably wrong in some way, as they would indicate a great motion, between 1781 and 1804, which is not sustained by the later observations.

Pos.	355° 40′	Dist. 2″.693	Epoch 1841.55	Mädler.

COMA BERENICES.

Berenice's Hair.—This is a beautiful cluster of small stars, situated about 5° E. of the equinoctial colure, and midway between Cor Caroli on the northeast, and Denebola on the southwest. If a straight line be drawn from Benetnasch through Cor Caroli, and produced to Denebola, it will pass through it.

The principal stars are of between the 4th and 5th magnitudes. According to Flamsted, there are thirteen of the 4th magnitude, and, according to others, there are seven; but the student will find, agreeably to his map, that there are but *three* stars in this group entitled to that rank.

Although it is not easy to mistake this group for any other in the same region of the skies, yet the stars which compose it are all so small as to be rarely distinguished in the full presence of the moon. The confused luster of this assemblage of small stars, somewhat resembles that of the Milky-Way. It contains, besides the stars already alluded to, a number of nebulæ.

The whole number of stars in this constellation is 43; its mean right ascension is 185°. It, consequently, is on the meridian the 13th of May.

———————" Now behold
The glittering maze of *Berenice's Hair ;*
Forty the stars ; but such as seem to kiss
The *flowing tresses* with a lambent fire:
Four to the telescope alone are seen."

TELESCOPIC OBJECTS.

35 Comæ Bernices.—A. R. = 12 h. 45 m. 25 s. Dec. = + 22° 07′. A triple star, between the Tresses and Virgo's northern wing. A 5, B indistinct, C 10. Such are the magnitudes assigned by Captain Smyth. I measured the components on the 27th July, 1847, and found the individual measures accord well with each other.

Pos. A B = 40° 04′ Dist. = 1″.316 Epoch as above.
A to C 125 31

In 1830, Strüve gives the measures of A to C as follows:

Pos. A to C 124° 43′ Dist. 28″.61 Epoch 1830.13.

Captain Smyth makes the distance between A and B, in 1834, 1″.00. In 1843, 1″.5.

64 Messier, Comæ Bernices.—A. R. = 12 h. 48 m. 52 s. Dec. + 22° 33′ 02″. A large elliptical nebula, between Bernice's hair and Virgo's left arm.

Discovered by Messier, 1780.

Sir John Herschel considers this nebula resolvable, though not resolved. He says: "I am much mistaken if the nucleus be not a double star, in the general direction of the nucleus; 320 much increases this suspicion ; 340 shows well a vacuity below the nucleus."

53 Messier, Comæ Bernices.—A. R. = 13 h. 05 m. 03 s. Dec. = + 19° 01′ 03″. A globular cluster, between the Coma and Virgo's left hand. A brilliant mass of minute stars, varying from the 11th to the 16th magnitudes.

Discovered by Messier, 1774. Resolved by Herschel, who finds it greatly compressed at the center. This is one of the many magnificent "island universes."

Sir John Herschel, with his 20 feet reflector, saw this object with curved radiations of stars, somewhat resembling the claws of a crab.

42 Comæ Bernices.—A. R. = 13 h. 02 m. 12 s. Dec. = + 18° 22′ 06″. A very close double star, between the Lady's hair and Virgo's left hand. A 4½, B 5, magnitude. Both stars are said to be pale-yellow. It is No. 1728 of Strüve's great catalogue, and is among his "vicinissimæ," or very closest stars.

The measures run thus:

Pos.	09° 30′	Dist.		Epoch 1827.83	Strüve.
	11 06		0″.649	1829.40	
	— —		single	1833.37	
	228 18		somewhat elongated	1834.43	
	191 12			1335.39	

After this, the measures are made with little variation, up to 1841, when Mädler, of Dorpat, gives these:

Pos. 183° 15′ Dist. 0″.327 Epoch 1841.45.

Here is, doubtless, a binary system, but one of great difficulty. The stars being nearly equal in magnitude, it is difficult to distinguish the angle of position from the same, increased by 180°.

ASTERION ET CHARA; VEL CANES VENATICI.

The Greyhounds. — This modern constellation, embracing two in one, was made by Hevelius out of the unformed stars of the ancients, which were scattered between Boötes on the east, and Ursa Major on the west, and between the handle of the Dipper on the north, and Coma Berenices on the south.

These Hounds are represented on the celestial sphere as being in pursuit of the Great Bear, which Boötes is hunting round the pole of heaven, while he holds in his hand the leash by which they are fastened together. The northern one is called *Asterion*, and the southern one *Chara*.

The stars in this group are considerably scattered, and are principally of the 5th and 6th magnitudes; of the twenty-five stars which it contains, there is but one sufficiently large to engage our attention. *Cor Caroli*, marked α, or *Charles's Heart*, so named by Sir Charles Scarborough, in memory of King Charles the First, is a star of the 3d magnitude, in the neck of Chara, the southern Hound.

When on the meridian, Cor Caroli is 17½° directly south of Alioth, the third star in the handle of the Dipper, and is so nearly on the same meridian, that it culminates only one minute and a half after it. This occurs on the 20th of May.

A line drawn from Cor Caroli, through Alioth, will lead to the north polar star. This star may also be readily distinguished by its being in a straight line with, and midway between, Benetnasch, the first star in the handle of the Dipper, and Coma Berenices: and, also, by the fact that, when Cor Caroli is on the meridian, Denebola bears 28° S. W., and Arcturus 26° S. E. of it, forming, with these two stars, a very large triangle, whose vertex is at the north. It is also at the northern extremity of the large Diamond, already described.

The remaining stars in this constellation are too small, and too much scattered, to excite our interest.

TELESCOPIC OBJECTS.

2 Canum Venaticorum.—A. R. = 12 h. 08 m. 06 s. Dec. = + 41° 33′. A double star, near Chara's mouth. A 6, yellow; B 9, blue. Discovered by Herschel, 1782.

Pos. 259° 38′ Dist. 11″.42 Epoch 1832.16 Struve.

Its fixity seems to be determined by a comparison of all the recorded observations.

A Large Nebula.—A. R. = 12 h. 43 m. 2? s. Dec. 41° 59′ 07″. Immediately preceding the Crown, or Charles's Heart.

Discovered by Michain, in 1781. Described in the Bedford Catalogue as "a fine pale white object, with evident symptoms of being a compressed cluster of small stars."

51 M. Canum Venaticorum.—A. R. = 13 h. 23 m. 06 s. Dec. = + 48° 01′ 07″. A pair of lucid nebula, near the ear of Asterion.

Discovered by Messier, 1772. Figured by Sir John Herschel, 1830. Resolved by Lord Rosse, into one magnificent cluster, in the shape of an immense whirlpool, in 1847.

I have repeatedly examined this most wonderful object with the 12 inch refractor of the Cincinnati Observatory. The large nebula is seen with a bright nucleus, surrounded by a ring of hazy light, which is divided, in a part of its circumference, into two branches, which forcibly remind me of the Milky-Way and its division. The smaller nebula is round, and its light is seen nearly, if not quite, commingling with that of the ring surrounding the principal object. This object strongly resembled our own great stellar system, so long as it was viewed at the distance to which ordinary telescopes could carry the beholder. But, under the gaze of Lord Rosse's stupendous reflector, the most bewildering object bursts upon the sight. A mighty center, where, in spiral curves, radiate masses of light, so vast as to overwhelm the imagination.

The resolution of this most remarkable nebula is one of the great achievements of Lord Rosse's telescope.

3 Messier, Canum Venaticorum.—A. R. = 13 h. 34 m. 45 s. Dec. = + 29° 10′ 06″. A magnificent cluster, said to contain not less than a thousand stars, between the southern Hound and the knee of Boötes.

Discovered by Messier, 1764; and described as "a nebula without a star, brilliant and round." Resolved by Herschel, 1784, with his 20 feet reflector, who calls it "a beautiful cluster of stars, 5′ or 6′ in diameter." I have repeatedly examined this fine object. The mass of stars is greatly compacted together at the center, and spread out in brilliant radiations in all directions. The largest radiations extend downward, as seen with an inverting eye-piece.

CORONA BOREALIS.

The Northern Crown.—This beautiful constellation may be easily known by means of its six principal stars, which are so placed as to form a circular figure, very much resembling a wreath or crown. It is situated directly north of the Serpent's head, between Boötes, on the west, and Hercules, on the east.

This asterism was known to the Hebrews by the name of *Ashtaroth*; and by this name the stars in Corona Borealis are called, in the East, to this day.

Alphacca, marked α, of the 2d magnitude, is the brightest and middle star in the diadem, and about 11° E. of Mirac, in Boötes. It is very readily distinguished from the others, both on account of its position and superior brilliancy. Alphacca, Arcturus and Seginus, form nearly an isosceles triangle, the vertex of which is at Arcturus.

This constellation contains twenty-one stars, of which only six or eight are conspicuous; and most of these are not larger than the third magnitude. Its mean declination is 30° north, and its mean right ascension 235°. Its center is, therefore, on the meridian about the last of June, and the first of July.

> "And, near to *Helice*, effulgent rays
> Beam, *Ariadne*, from thy starry crown:
> *Twenty* and *one* her stars; but eight alone
> Conspicuous; *one* doubtful, or to claim
> The second order, or accept the third."

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. XIV.

LEO MINOR—THE LITTLE LION.
LYNX—THE LYNX.

Favorably situated for examination in March, April and May.

LEO MINOR.

THE LITTLE LION.—This constellation was formed by Hevelius, out of the *Stellæ informes*, or unformed stars of the ancients, which lay scattered between the zodiacal constellation Leo, on the south, and Ursa Major, on the north. Its mean right ascension is the same with that of Regulus, and it comes to the meridian at the same time, on the 6th of April.

The modern constellations, or those which have been added to our celestial maps, since the adoption of the Greek notation, in 1603, are referred to by the letters of the English alphabet, instead of the Greek. This is the case in regard to Leo Minor, and all other constellations whose origin is subsequent to that period.

Leo Minor contains fifty-three stars, including only two of the 4th magnitude. The principal star is situated in the body of the animal, 13° north of Gamma Leonis, in a straight line with Phad, and may be known by a group of smaller stars, a little above it, on the northwest.

It forms an equilateral triangle with Gamma and Delta Leonis, the vertex being in Leo Minor. This star is marked with the letter *l*, in modern catalogues, and, being the principal representative of the constellation, is itself sometimes called the Little Lion: 8° E. of this star (the Little Lion), are two stars of the 4th magnitude, in the last paw of Ursa Major; and about 10° N. W. of it, are two other stars, of the 3d magnitude, in the first hind paw.

> "The *Smaller Lion* now succeeds; a cohort
> Of fifty stars attends his steps;
> And *three*, to sight unarmed, invisible."

TELESCOPIC OBJECTS.

200 Herschel I, Leonis Minoris.—A. R. = 8 h. 42 m. 44 s. Dec. = + 34° 00′ 06″. A bright oval nebula, between Lynx and Cancer.

Discovered by Herschel, 1787; and registered as a very beautiful nebula, 8′ long and 3′ broad.

Other nebula will be found on the chart.

THE LYNX.

The constellation of the Lynx, like that of the Camelopard, exhibits no very interesting features, by which it can be distinguished. It contains only a moderate number of inferior stars, scattered over a large space, north of Gemini and between Auriga and Ursa Major. The whole number is forty-four, including only three that are so large as the 4th magnitude. The largest of these, in the nose, is in the solstitial colure, 14° north of Menkalina, in the east shoulder of Auriga. The other two principal stars are in the brush of the tail, 3½° south-west of another star, of the same brightness, in the mouth of the Lesser Lion, with which it makes a small triangle. Its center is on the meridian at 9 o'clock, on the 23d, or, at half-past 7, on the 1st, of February

TELESCOPIC OBJECTS.

4 Lyncis.—A. R. = 6 h. 07 m. 51 s. Dec. = + 59° 25′ 08″. A close double star, in the nose of the Lynx. A 6, B 7½.

Discovered by Strüve.

Pos. 88° 56′ Dist. 0″.815 Epoch 1830.28 Strüve.

174 P. VI, Lyncis.—A. R. = 6 h. 30 m. 42 s. Dec. + 59° 35′ 06″. A double star, under the eye of the Lynx. A 7½, white, B 10, blue.

Discovered by Strüve.

Pos. 133° 28′ Dist. 4″.197 Epoch 1830.58.

The companion appears to be variable, ranging from 8½ to the 12th magnitude.

14 Lyncis.—A. R. 6 h. 38 m. 57 s. Dec. = 59° 37′ 06″ A close

double star, under the eye of the Lynx. A 5½, "golden yellow," B 1, "purple."

Discovered by Strüve.

Pos. 50° 51′ Dist. 0″ 897 Epoch 1830.88

137. Herschel I, Lyncis.—A. R. = 09 h. 14 m. 32 s. Dec. + 35° 11′ 09″. A bright nebula, on the fore paws of Leo Minor, but included within the limits of the Lynx.

Discovered by Herschel, in 1786, who describes it as round, pale white, and sparkling in the center, with an additional faint nebulosity surrounding the nucleus. Some 3′ in diameter.

DIRECTIONS FOR TRACING THE CONSTELLATION ON

MAP NO. XV.

Libra—The Scales.

Favorably situated for examination in May, June and July.

LIBRA.

The Balance.—This is the seventh sign, and eighth constellation, from the vernal equinox, and is situated in the Zodiac, next east of Virgo.

The sun enters this *sign*, at the autumnal equinox, on the 23d of September; but does not reach the *constellation* before the 27th of October.

Virgo was the goddess of justice, and Libra, the scales, which she is usually represented as holding in her left hand, are the appropriate emblems of her office. When the sun enters the sign Libra, the days and nights are equal all over the world, and seem to observe a kind of equilibrium, like a balance.

When, however, it is said that the vernal and autumnal equinoxes are in Aries and Libra, and the tropics in Cancer and Capricorn, it must be remembered that the *signs*, Aries and Libra, Cancer and

Capricorn, and not the constellations of these na nes, are meant; for the equinoxes are now in the constellations Pisces and Virgo, and the tropics in Gemini and Sagittarius; *each constellation having gone forward one sign in the ecliptic.*

About twenty-two centuries ago, the *constellation* Libra coincided with the *sign* Libra; but, having advanced 30°, or more, in the ecliptic, it is now in the *sign* Scorpio, and the constellation Scorpio is in the *sign* Sagittarius, and so on.

While Aries is now advanced a whole sign above the equinoctial point, into north declination, Libra has descended as far below it, into south declination.

Libra contains fifty-one stars, including two of the 2d magnitude, and several of the 4th. Its mean declination is 8° south, and its mean right ascension 226°. Its center is, therefore, on the meridian about the 22d of June.

It may be known by means of its four principal stars, forming a quadrilateral figure, lying northeast and southwest, and having its upper and lower corners nearly in a line running north and south. The two stars which form the northeast side of the square are situated about 7° apart, and distinguish the northern scale. The two stars which form the southwest side of the square are situated about 6° apart, and distinguish the southern scale.

Zubeneschamali, marked β, in the northern scale, about 21° E. of Spica, and 8° E. of Lambda Virginis, is a star of the 2d magnitude, and is situated very near the ecliptic, about 42½° E. of the autumnal equinox. The distance from this star down to Theta Centauri, is about 23°, with which, and Spica Virginis, it forms a large triangle, on the right.

Zubenelgemabi, marked α, is also of the 2d magnitude, 9½° below Zubeneschamali, towards the southwest, and it comes to the meridian about twenty-six minutes after it, on the 23d of June. Zubenelgemabi is the northernmost of the four bright stars in this figure, and is exactly opposite the lower one, which is 11° S. of it.

The star marked γ, is a star of the 3d magnitude, in the northern scale, 7° S. E. of Zubenelgemabi, and nearly opposite to Zubeneschamali, at the distance of 11° on the east. These two make the diagonal of the square east and west.

Iota is a star of the 4th magnitude, and constitutes the southernmost corner of the square. It is about 6° S. E. of Zubeneschamali, and 11° S of Zubenelgemabi, with which it forms the other diagonal, north and south.

Zubenelgubi is a star of the 2d magnitude, situated below the southern scale, at the distance of 6° from Iota, and marks the southern limit of the Zodiac. It is situated in a right line with, and nearly midway between, Spica Virginis and Beta Scorpii; — and comes to the meridian nearly at the same moment with Nekkar, in the head of Boötes.

The remaining stars in the constellation are too small to engage attention.

The scholar, in tracing out this constellation in the heavens, will perceive that Lambda and Mu, which lie in the feet of Virgo, on the west, form, with Zubeneschamali and Zubenelgemabi, almost as handsome and perfect a figure as the other two stars in the Balance do, on the east.

TELESCOPIC OBJECTS.

A Double Star.—A. R. = 14 h. 14 m. 11 s. Dec. = — 07° 01′ 07″.—15°, east by north, from Spica Virginis. The stars are equal, and of the 8th magnitude

Pos. 166° 08′ Dist. 5″.02 Epoch 1836.44 Smyth.

A Close Double Star.—A. R. = 14 h. 16 m. 06 s. Dec. 10° 56′ 03″.—Close to the heel of the Virgin. A 7½, yellow, B 9½, greenish. Discovered by Strüve, 1827.

Pos. 326° 87′ Dist. 1″.41 Epoch 1829.83.

A Closely Compacted Cluster.—A. R. = 15 h. 10 m. 26 s. Dec. = + 02° 41′ 03″. Over the Balance.

Discovered by Messier, 1764, who registers it as a round nebula, in which, he is confident, not a star exists; and yet, in May, 1791, Sir William Herschel, by the aid of his 40 feet reflector, counted in this object no less than 200 stars.

This is one of the great clusters comparatively near our sidereal stratum, and somewhat resembling that in Hercules, hereafter described and figured. The drawing was made under a power of 280, and 12 inches aperture, the object was thus described.

ξ or 51 Libræ.—A. R. = 15 h. 58 m. 35 s. Dec. = — 10° 55 06″. A most elegant triple star, between the upper *scale* of Libra and the right leg of Ophiuchus. A 4½, B 5, magnitude.

		Pos.	Dist.	Epoch	
Pos.	A B	187° 56′	1″ .50	1782.36	Herschel.
	A C	88 37	6 .38	1780.39	
	A B	355 58	1 .147	1825.48	Strüve.
	A C	78 36	6 .75	——	
	A B	16 43	1 .28	1841.48	Mädler.
	A C	74 40	6 .75	——	
	A B	24 52	0 .97	1846.48	Mitchel.
	A C	74 42	7 .16	——	

The disks are perfect, with a power of 600 times.

A LARGE COMPRESSED CLUSTER.—A. R. = 15 h. 08 m. 06 s. Dec. = − 20° 26′ 07″.
Discovered by Herschel, 1785. It forms a sort of connecting link between the congeries of stars and the distant nebulæ.

DIRECTIONS FOR TRACING THE CONSTELLATION ON

MAP NO. XVI.

SCORPIO—THE SCORPION.

Favorably situated for examination in June, July, and August.

SCORPIO.

THE SCORPION.—This is the eighth sign, and ninth constellation, in the order of the Zodiac. It presents one of the most interesting groups of stars, for the pupil to trace out, that is to be found in the southern hemisphere. It is situated southward and eastward of Libra, and is on the meridian the 10th of July.

The sun enters this *sign* on the 23d of October, but does not reach the *constellation* before the 20th of November. When astronomy was first cultivated in the East, the two solstices and the two equinoxes took place when the sun was in Aquarius and Leo, Taurus and Scorpio, respectively.

Scorpio contains, according to Flamsted, forty-four stars; including one of the 1st magnitude, one of the 2d, and eleven of the 3d. It is readily distinguished from all others, by the peculiar luster and the position of its principal stars.

Antares, marked α, is the principal star, and is situated in the heart of the Scorpion, about 19° E. of Zubenelgubi, the southernmost star in the Balance. Antares is the most brilliant star in that region of the skies, and may be otherwise distinguished by its remarkably red appearance. Its declination is about 26° S. It comes to the meridian about three hours after Spica Virginis, or fifty minutes after Corona Borealis, on the 10th of July. It is one of the stars from which the moon's distance is reckoned, for computing the longitude at sea.

There are four great stars in the heavens, *Fomalhaut, Aldebaran, Regulus,* and *Antares,* which formerly answered to the solstitial and equinoctial points, and which were much noticed by the astronomers of the East.

About 8½° N. W. of Antares, is a star of the 2d magnitude, in the head of the Scorpion, called *Graffias,* marked β. It is but 1° N. of the earth's orbit. It may be recognized by means of a small star, situated about 1° N. E. of it, and also by its forming a slight curve with two other stars of the 3d magnitude, situated below it, each about 3° apart. The broad part of the constellation near Graffias is powdered with numerous small stars, converging down to a point at Antares, and resembling in figure a boy's kite.

As you proceed from Antares, there are ten conspicuous stars, chiefly of the 3d magnitude, which mark the tail of the kite, extending down, first in a south-southeasterly direction, about 17°, thence easterly, about 8° further, when they turn, and advance about 8° towards the north, forming a curve, like a shepherd's crook, or the bottom part of the letter S. This crooked line of stars, forming the tail of the Scorpion, is very conspicuous, and may be easily traced.

The first star below Antares, which is the last in the back, is of only the 4th magnitude. It is about 2° S. E. of Antares, and is marked τ.

Epsilon, of the 3d magnitude, is the second star from Antares, and the first in the tail. It is situated about 7° below the star τ, but inclining a little to the east.

Mu, of the 3d magnitude, is the 3d star from Antares. It is situated

4½° below Epsilon. It may otherwise be known by means of a small star close by it, on the left.

Zeta, of about the same magnitude, and situated about as far below Mu, is the fourth star from Antares. Here the line turns suddenly to the east.

Eta, also of the 3d magnitude, is the fifth star from Antares, and about 3½° east of Zeta.

Theta, of the same magnitude, is the sixth star from Antares, and about 4½° E. of Eta. Here the line turns again, curving to the north, and terminates in a couple of stars.

Iota, is the seventh star from Antares, 3½° above Theta, curving a little to the left. It is a star of the 3d magnitude, and may be known by means of a small star almost touching it, on the east.

Kappa, a star of equal brightness, is less than 2° above Iota, and a little to the right.

Lesuth, of the 3d magnitude, is the brightest of the two last in the tail, and is situated about 3° above Kappa, still further to the right. It may readily be known by means of a smaller star close by it, on the west.

This is a very beautiful group of stars, and easily traced out in the heavens: It furnishes striking evidence of the facility with which most of the constellations may be so accurately delineated as to preclude every thing like uncertainty in the knowledge of their relative situation.

"The heart, with luster of amazing force,
Refulgent vibrates; faint the other parts,
And ill-defined by stars of meaner note."

TELESCOPIC OBJECTS.

Antares, or α Scorpii.—A. R. = 16 h. 19 m. 36 s. Dec. = — 26° 04′ 03″.

Discovered to be double, at the Cincinnati Observatory, July, 1845. A 1, orange, B 12, blue. The contrast of color is distinctly marked. The small star follows the principal one on the same parallel. Distance 2″.5. The principal star was pronounced to be double, by the Washington observers, in August, 1846, but this error has been subsequently corrected. This forms the most remarkable double star now on the catalogues,—there being no star of the 1st magnitude known, having so minute a companion, at so short a distance.

It was first divided with a power of 250, and aperture of 12 inches. The best power for measures is 500, with an aperture reduced to 9 inches. My measures indicate a slight increase in the distance between the two components. This, however, requires confirmation.

ν Scorpii.=A. R. = 16 h. 02 m. 42 s. Dec. = — 19° 02′ 03″. Registered as a double star. Discovered to be triple, at the Cincinnati

Observatory, 1846. A and B nearly equal, and of the 6th magnitude; C 7, magnitude.

Distance from A to B = 1″.2 From $\frac{A + B}{2}$ to C 40″.00

Pos. $\frac{A + B}{2}$ to C = 338° 29′

From A to B = 37 57

This star was first seen double by Herschel, in 1779; but its great southern declination brought it too near the horizon, in the latitude of his observatory, to see the close stars. The same may be said of Antares. I have recently received intelligence, that measures of Antares have been made in England, 1847.

σ Scorpii.—A. R. = 16 h. 11 m. 28 s. Dec. = — 25° 12′ 02″. A delicate double star, 2° W. by N. from Antares. A 4, B 9½, mag. Pos. 271° 05′ Dist. 20″.04

Discovered by Herschel, 1783. There is no evidence of any change in the relative position of the components.

Pos. 271° 05′ Dist. 22″.34 Epoch 1817.60 Mitchel.

β Scorpii.—A. R. = 15 h. 56 m. 08 s. Dec. = — 19° 21′ 07″. A second rate Greenwich star. Discovered to be double by Herschel, 1779. A 2, B 5½, magnitude. Mädler thinks this a binary system of long period. The measures are as follow:

Pos. 25° 09′	Dist. 14″.37	Epoch 1779.72	Herschel.
26 30	13 .65	1823.28	Her. & South.

My own measures are:

Pos. 26° 22′ Dist. 13″.68 Epoch 1846.50. Agreeing nearly with Herschel and South.

The Bedford Catalogue gives:

Pos. 24° 09′ Dist. 13″.01 Epoch 1835.39.

From these measures, there is very little evidence of any change, either in distance or angle of position.

A Large and Brilliant Cluster.—A. R. = 16 h. 07 m. 28 s. Dec. — 22° 35′ 04″.

Discovered by Messier, in 1780, who describes it as resembling the nucleus of a comet. It is 4° E. of δ Scorpii. and midway between α and β. It is remarkable as being located on the western edge of an immense opening, or vacant spot, in the heavens, of 4° in breadth, in which the most powerful telescopes reveal no stars! The center of this cluster is very brilliant, and the surrounding points of light profusely scattered Herschel regards it as one of the richest and most condensed masses of stars yet discovered in the heavens. Examined and figured, 2d August, 1847.

A Small Compressed Cluster.—A. R. = 16 h. 13 m. 51 s. Dec. = — 26° 07′ 05″. It precedes Antares 1½° on the same parallel. Discovered by Messier. Resolved by Herschel; who estimates its profundity of the 344th order.

This condensed group is also on the western edge of the opening above referred to, and has given rise to the following remarks by Arago, referring to the idea expressed by Herschel, that, wherever chasms in the heavens are found, near by, extensive clusters and nebula will be discovered.

"Let us," says M. Arago, "connect these facts with the observation which has shown that the stars are greatly condensed toward the center of the spherical clusters, and with that which has afforded the proof that these stars sensibly obey a certain power of condensation (or clustering power), and we shall feel disposed to admit, with Herschel, that nebulæ are formed sometimes, by the incessant operation of a great number of ages, at the expense of the scattered stars which originally occupied the surrounding regions; and the existence of empty or *ravaged* spaces—to use the picturesque expression of the great astronomer, will no longer present any thing which will confound the imagination"

A Large Resolvable Nebula.—A. R. = 16 h. 51 m. 04 s. Dec. —29° 50′ 06″.

Discovered by Messier. Resolved by Herschel; who estimates its distance to be of the 734th order. It resembles a comet, and has been reported as such, at least once, in a very public manner.

All the reported clusters in this constellation are readily detected by any ordinary telescope. Their resolution does not require a high power. But to show them in all their richness and brilliancy, a powerful instrument is necessary.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. XVII.

Ursa Minor—The Lesser Bear.
Cepheus.
Camelopardus—The Camelopard.

Favorably situated for examination in March, April, and May.

URSA MINOR.

The Little Bear.—This constellation, though not remarkable in its appearance, and containing but few conspicuous stars, is, nevertheless, justly distinguished from all others, for the peculiar advantages which its position in the heavens is well known to afford to nautical astronomy, and especially to navigation and surveying.

The stars in this group being situated near the celestial pole, appear to revolve about it, very slowly, and in circles so small as never to descend below the horizon.

In all ages of the world, this constellation has been more universally observed, and more carefully noticed than any other, on account of the importance which mankind early attached to the position of its principal star.

This star, which is so near the true pole of the heavens, has from time immemorial, been denominated the North Polar Star. By the Greeks it is called *Cynosure:* by the Romans, *Cynosura*, and by othes nations, *Alruccabah*.

It is of the 3d magnitude, or between the 2d and 3d, and situated a little more than a degree and a half from the true pole of the heavens, on that side of it which is towards Cassiopeia, and opposite to Ursa Major. Its position is pointed out by the direction of the two *Pointers*, Merak and Dubhe, which lie in the square of Ursa Major. A line joining β Cassiopeia, which lies at the distance of 32° on one side, and Megrez, which lies at the same distance on the other side, will pass through the polar star.

So general is the popular notion, that the North Polar Star is the true pole of the world, that even surveyors and navigators, who have acquired considerable dexterity in the use of the compass and the quadrant, are not aware that it ever had any deviation, and consequently never make allowance for any. All calculations derived from the observed position of this star, which are founded upon the idea that its bearing is always due north of any place, are necessarily erroneous, since it is in this position only twice in twenty-four hours; once when above, and once when below the pole.

According to the Nautical Almanac, the mean distance of this star from the true pole of the heavens, for the 1st Jan. 1849, is 1° 29′ 28″, and its mean right ascension is 1 h. 5 m. and 10.66 s. Consequently, when the right ascension of the meridian of any place is 1 h. 5 m. and 10.66 s. the star will be exactly on the meridian at that time and place, but 1° 29′ 28″ *above* the true pole. Six hours after, when the right ascension of the meridian is 7 h. 5 m. and 10.66 s. the star will be at its greatest elongation, or 1° 29′ 28″ directly *west* of the true pole, and parallel to it, with respect to the horizon; and when the right ascension of the meridian is 13 h. 5 m. and 10.66 s. the star will be again on the meridian, but at the distance of 1° 29′ 28″ directly *below* the pole.

In like manner, when the right ascension of the meridian is 19 h. 5 m. and 10.66 s. the star will be at its greatest eastern elongation, or 1° 29′ 28″ *east* of the true pole; and when it has finished its revolution, and the right ascension of the meridian is 25 h. 5 m. and 10.66 s. or, what is the same thing, 1 h. 5 m. and 10.66 s. the star will now be on the meridian again, 1° 29′ 28″ above the pole.

N. B. The right ascension of the meridian or of the midheaven, is the distance of the first point of Aries from the meridian, at the time and place of observation. The right ascension of the meridian for any time, is found, by adding to the given time the sun's right ascension at the same time, and deducting 24 hours, when the sum exceeds 24 hours.

From the foregoing facts we learn, that from the time the star is on the meridian, above the pole, it deviates farther and farther from the true meridian, every hour, as it moves to the west, for the space of six hours, when it arrives at its greatest elongation west, whence it reäpproaches the same meridian below the pole, during the next six hours, and is then again on the meridian; being thus alternately half the time west of the meridian, and half the time east of it.

Hence, it is evident that the surveyor who regulates his compass by the North Polar Star, must take his observation when the star is on the meridian, either above or below the pole, or make allowance for its altered position in every other situation. For the same reason must the navigator, who applies his quadrant to this star for the purpose of determining the latitude he is in, make a similar allowance, according as its altitude is greater or less than the true pole of the heavens; for we have seen that it is alternately half the time *above* and half the time *below* the pole.

The method of finding the latitude of a place from the altitude of the polar star, as it is quite simple, is very often resorted to. Indeed, in northern latitudes, the situation of this star is more favorable for this purpose than that of any other of the heavenly bodies, because a single observation, taken at any hour of the night, with a good instrument, will give the true latitude, without any calculation or correction, except that of its polar aberration.

If the polar star always occupied that point in the heavens which is directly opposite to the north pole of the earth, it would be easy to understand how latitude could be determined from it in the northern hemisphere; for in this case, to a person on the equator, the poles of the world would be seen in the horizon. Consequently, the star would appear just visible in the northern horizon, without any elevation. Should the person now travel one degree towards the north, he would see one degree below the star, and he would think it had risen one degree.

And since we always see the whole of the upper hemisphere at one view, when there is nothing in the horizon to obstruct our vision, it follows that if we should travel 10° north of the equator, we should see just 10° below the pole, which would then appear to have risen 10°; and should we stop at the 42d degree of north latitude, we should, in like manner, have our horizon just 42° below the pole, or the pole would appear to have an elevation of 42°. Whence we derive this general truth: *The elevation of the pole of the equator, is always equal to the latitude of the place of observation.*

Any instrument, then, which will give us the altitude of the north pole, will give us also the latitude of the place.

The method of illustrating this phenomenon, as given in most treatises on the globe, and as adopted by teachers generally, is to tell the scholar that the north pole rises higher and higher, as he travels farther and farther towards it. In other words, whatever number of degrees he advances *towards* the north pole, so many degrees will it rise above his horizon. This is not only an obvious *error* in principle, but it misleads the apprehension of the pupil. It is *not* that the *pole is elevated*, but that our *horizon is depressed* as we advance towards the north. The same objection lies against the artificial globe; for it ought to be so fixed that the *horizon* might be raised or depressed, and the pole remain in its own invariable position.

Ursa Minor contains twenty-four stars, including three of the 3d magnitude and four of the 4th. The seven principal stars are so situated as to form a figure very much resembling that in the Great Bear, only that the *Dipper* is reversed, and about one half as large as the one in that constellation.

The first star in the handle, called *Cynosura*, or *Alruccabah*, is the polar star, around which the rest constantly revolve. The two last in the bowl of the Dipper, corresponding to the *Pointers* in the Great Bear, are of the 3d magnitude, and situated about 15° from the pole. The brightest of them is called Kochab, which signifies an axle or hinge, probably in reference to its moving so near the axis of the earth.

Kochab may be easily known by its being the brightest and middle one of three conspicuous stars forming a row, one of which is about 2°, and the other 3°, from Kochab. The two brightest of these are situated in the breast and shoulder of the animal, about 3° apart, and are called the *Guards* or *Pointers* of Ursa Minor. They are on the meridian about the 20th of June, but may be seen at all hours of the night, when the sky is clear.

Of the four stars which form the bowl of the Dipper, one is so small as hardly to be seen. They lie in a direction towards Gamma in Cepheus; but as they are continually changing their position in the heavens, they may be much better traced out from the map, than from description.

Kochab is about 25° distant from Benetnasch, and about 24° from Dubhe, and hence forms with them a very nearly equilateral triangle.

> ——— "The Lesser Bear
> Leads from the pole the lucid band; the stars
> Which form this constellation, faintly shine,
> Twice twelve in number; only one beams forth
> Conspicuous in high splendor, named by Greece
> The *Cynosure;* by us the POLAR STAR."

The following stars have small telescopic companions: α or the pole star. β or Kochab, the right hand upper star in the bowl of the little dipper. ζ The left hand upper star in the bowl. The companion discovered 1841, by Prof. Challis, with the Northumberland equatorial, at Cambridge, England. ϵ The star near the root of the tail. Companion 12th magnitude, pale blue. δ The star next but one to Polaris, in the tail. The principal star is of a greenish tinge, while the companion is grey. There are a few faint nebulæ in this constellation.

CEPHEUS.

CEPHEUS is represented on the map as a king, in his royal robe, with a scepter in his left hand, and a crown of stars upon his head. He stands in a commanding posture, with his left foot over the pole, and his scepter extended towards Cassiopeia, as if for favor and defense of the queen.

> ——— "Cepheus illumes
> The neighboring heavens; still faithful to his queen,
> With thirty-five faint luminaries mark'd."

This constellation is about 25° N. W. of Cassiopeia, near the 2d coil of Draco, and is *on* the meridian at 8 o'clock the 3d of November; but it will linger *near* it for many days. Like Cassiopeia, it may be seen at all hours of the night, when the sky is clear, for to us it never sets.

By reference to the lines on the map, which all meet in the pole, it will be evident that a star, near the pole, moves over a *much less* space in one hour, than one at the equinoctial; and generally, the *nearer* the pole, the *narrower* the space, and the *slower* the motion.

The stars that are so near the pole, may be better described by their *polar distance*, than by their declination. By polar distance, is meant—the *distance* from the pole; and is what the declination wants of 90°.

In this constellation there are 35 stars visible to the naked eye; of these, there glitters on the shoulder, a star of the 3d magnitude, called *Alderamin*, marked α, which with two others of the same brightness, 8° and 12° degrees apart, form a slightly curved line towards the N. E. The last, whose *letter* name is Kappa, is in the right knee, 19° N. of Caph, in Cassiopeia. The middle one in the line, is Alphirk, marked β, in the girdle. This star is one-third of the distance from Alderamin to the pole, and nearly in the same right line.

It cannot be too well understood that the bearings, or directions of one star from another, as given in this treatise, are strictly applicable only when the former one is on, or near the meridian. The bearings given, in many cases, are the least approximations to what appears to be their relative position; and in some, if relied upon, will lead to errors. For example:—It is said, in the preceding paragraph, that Kappa, in Cepheüs, bears 19° N. of Caph in Cassiopeia. This is true, when Caph is on the meridian, but at this very moment, while the author is writing this line, Kappa *appears* to be 19° *due west* of Caph; and six months hence, will appear to be the same distance *east* of it. The reason is obvious; the circle which Cepheüs appears to describe about the pole, is *within* that of Cassiopeia, and consequently when on the east of the pole, will be *within*, or *between* Cassiopeia and the pole—that is, *west* of Cassiopeia. And for the same reason, when Cepheüs is on the west side of the pole, it is *between* that and Cassiopeia, or *east* of it.

Let it also be remembered, that in speaking of the *pole*, which we shall have frequent occasion to do, in the course of this work, the *North Polar Star*, or an imaginary point very near it, is always meant; and *not* as some will vaguely apprehend, a point *in the horizon*, directly N. of us. The true pole of the heavens, is always elevated just as many degrees *above* our horizon, as we are *north* of the Equator. If we live in 42° N. latitude, the N. pole will be 42° above our horizon. (*See North Polar Star.*)

There are also two smaller stars about 9° E. of

Alderamin and Alphirk, with which they form a square; Alderamin being the upper, and Alphirk the lower one on the W. 8° apart. In the *center* of this square there is a bright dot, or semi-visible star.

The *head* of Cepheus, is in the Milky-Way, and may be known by three stars of the 4th magnitude in the crown, which form a small acute triangle, about 9° to the right of Alderamin. The mean polar distance of the constellation is 25°, while that of Alderamin is 28° 10′. The right ascension of the former is 338°; consequently, it is 22° E. of the equinoctial colure.

TELESCOPIC OBJECTS.

κ CEPHEI.—A. R. = 20 h. 14 m. 08 s. Dec. = + 77° 13′ 06″. A fine double star on the right knee, about half-way from β Cephei to ι Ursæ Minoris. A $4\frac{1}{2}$, white, B $8\frac{1}{4}$, blue. The colors well defined.

Pos. 126° 12′	Dist. 07″.08	Epoch 1820.18	Strüve.
123 08	07 .50	1838.83	Smyth.

There is little evidence of any change in the position of the components.

β CEPHEI.—A. R. = 21 h. 26 m. 31 s. Dec. = + 69° 51′ 07″. A fine double star, on the left side of the girdle. A 3, B 8, magnitude.
Pos. 251° 00′ Dist. 13″.07 Epoch 1843.16 Smyth.

CAMELOPARDUS.

THE CAMELOPARD.—This constellation was made by Hevelius out of the unformed stars which lay scattered between Perseus, Auriga, the head of Ursa Major, and the Pole Star. It is situated directly N. of Auriga and the head of the Lynx, and occupies nearly all the space between these and the pole. It contains nearly 58 small stars; the five largest of which are only of the 4th magnitude. The principal star lies in the thigh, and is about 20° from Capella, in a northerly direction. It marks the northern boundary of the temperate zone; being less than one degree S. of the Arctic circle. There are two other stars of the 4th magnitude near the right knee, 12° N. E. of the first mentioned. They may be known by their standing 1° apart and alone.

The other stars in this constellation are too small, and too much scattered to invite observation.

TELESCOPIC OBJECTS.

A Bright Planetary Nebula.—A. R. = 03 h. 53 m. 29 s. Dec. 60° 23′ 05″. On the flank of the Camelopard. See map, No. VI.
Discovered by Herschel, 1787.

1 Camelopardi.—A. R. = 04 h. 19 m. 23′. Dec. = + 53° 33′ 03″. A double star between the hind hoofs. A 7½, "white," B 8½, "blue." See map, No. VI.
Pos. 307° 05′ Dist. 10″.13 Epoch 1830.57 Strüve.

2 Camelopardi.—A. R. = 04 h. 27 m. 18 s. Dec. 53° 09′ 00″. A close double star, near the preceding one, and between the hind hoofs. A 5½, yellow, B 7½, pale blue. See map, No. VI.
Discovered by Strüve, and thus measured by him:
Pos. 311° 40′ Dist. 1″.585 Epoch 1829.79.

A Double Star.—A. R. = 04 h. 56 m. 19 s. Dec. = + 79° 01′ 08″. Over the lower part of the back of the Camelopard. A 5½, B 9, magnitude.

Pos. 316° 23′	Dist. 37″.01	Epoch 1835.10	South.
319 01	33 80	1836.29	Smyth.

CHAPTER IV.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. XVIII.

SAGITTARIUS—THE ARCHER.
SCUTUM SOBIESKI—THE SHIELD OF SOBIESKI.

Favorably situated for examination in July, August, and September.

SAGITTARIUS.

THE ARCHER.—This is the ninth sign and the tenth constellation of the Zodiac. It is situated next east of Scorpio, with a mean declination of 35° S. or 12° below the ecliptic.

The sun enters this *sign* on the 22d of November, but does not reach the *constellation* before the 7th of December.

It occupies a considerable space in the southern hemisphere, and contains a number of subordinate, though very conspicuous stars. The whole number of its visible stars is sixty-nine, including five of the 3d magnitude, and ten of the 4th.

It may be readily distinguished by means of five stars of the 3d and 4th magnitudes, forming a figure resembling a little, short, straight-handled Dipper, turned nearly bottom upwards, with the handle to the west, familiarly called the *Milk-Dipper*, because it is partly in the Milky-Way.

This little figure is so conspicuous that it cannot easily be mistaken. It is situated about 33° E. of Antares, and comes to the meridian a few minutes after Lyra, on the 17th of August. Of the four stars forming the bowl of the Dipper, the two upper ones are only 3° apart, and the lower ones 5°.

The two smaller stars forming the handle, and extending westwardly about 4½°, and the easternmost one in the bowl of the Dipper, are all of the 4th magnitude. The star in the end of the handle, is marked λ, and is placed in the bow of Sagittarius, just within the Milky Way. Lambda may otherwise be known by its being nearly in a line with two other stars about 4½° apart, extending towards the S. E. It is also equidistant from ϕ and δ, with which it makes a handsome triangle, with the vertex in λ. About 5° above λ, and a little to the west, are two stars close together, in the end of the bow, the brightest of which is of the 4th magnitude, and marked μ. This star serves to point out the winter solstice, being about 2° North of the tropic of Capricorn, and less than one degree east of the solstitial colure.

If a line be drawn from σ through ϕ, and produced about 6° farther to the west, it will point out δ, and produced about 3° from δ, it will point out γ; stars of the 3d magnitude, in the arrow. The latter is in the point of the arrow, and may be known by means of a small star just above it, on the right. This star is so nearly on the same meridian with Etanin, in the head of Draco, that it culminates only two minutes after it.

A few other conspicuous stars in this constellation, forming a variety of geometrical figures, may be easily traced from the map.

TELESCOPIC OBJECTS.

A Cluster.—A. R. = 17 h. 55 m. 01 s. Dec. = — 22° 30′ 6″. Near the upper part of the bow of the Archer. It is a coarse cluster of small stars, forming a circular figure. It is 2½° S. E. of μ Sagittarii. Discovered by Messier, 1764.

μ Sagittarii.—A. R. = 18 h. 04 m. 11 s. Dec, — 21° 05′ 7″. A quadruple star on the north end of the Archer's bow. Registered as triple by the elder Herschel. Discovered to be quadruple by his son. A. 3½; B. 16; C. 9½; D. 10, magnitude.

Pos. A B	= 260° 0	Dist. 10″0	Estimations.
A C	= 315 0	40. 0	
A D	= 114 5	45. 0	

A Globular Cluster.—A. R. = 18 h. 14 m. 41 s. Dec. —24° 56′ 9″. Discovered by Messier, 1764. Resolved by Sir W. Herschel. It is not very bright, but constitutes a good test for space penetrating power. It is between the Head and Bow of the Archer, and is midway between β Ophiuchi and β Lyræ.

A Loose Cluster.—A. R. = 18 h. 22 m. 14 s. Dec. — 19° 10′ 2″. Between the Archer's head and the shield of Sobeiski. "The gathering portion of the group assumes an arched form, and is thickly strewn in the upper part of the field, where a pretty knot of minute glimmerers occupies the center, with much star dust around." It is 5° N. E. of μ Sagittarii.

A Globular Cluster.—A. R. = 18 h. 26 m. 25 s. Dec. — 24° 01′ 4″. In the space between the head and bow of Sagittarius, midway between μ and σ Sagittarii. Drawn by Le Gentil in August, 1774. Described by Messier, 1764, as a "nebula without a star." Resolved by Sir W. Herschel, and estimated as of the 344th order of distances.

54 Sagittarii.—A. R. = 19 h. 31 m. 33 s. Dec. —16° 29′ 2″. A delicate triple star in the space between the heads of Capricorn and the Archer. A $5\frac{1}{2}$; B 8; C 16; magnitude.

Discovered by Sir John Herschel

Pos.	A B	= 42° 8	Dist. 28′.5	Estimated 1837.58
	A C	= 280 0	20.0	

A Pale Blue Planetary Nebula.—A. R. = 19 h. 34 m. 56 s. Dec. = — 14° 31′ 6″. Between the heads of Capricorn and Sagittarius. Discovered by Sir W. Herschel, 1787. I examined this object 7th July, 1847. It is a little elongated, very sharply illuminated, and well defined. There are several small stars in the field of view. The bluish tint of the planetary nebula is well marked, and offers another point of analogy with the planets. Herschel and Neptune are marked by their blue tint, and indeed I am confident that Neptune was seen at the Cincinnati Observatory a year before its discovery. It was thought to be a planetary nebula, and was lost from the field of view by accident before its position was taken. But the region of space was well remembered, and the moment I saw the planet it looked familiar.

A Globular Cluster.—A. R. = 19 h. 56 m. 38 s. Dec. = — 22° 22′ 0″. Between the left arm of Sagittarius and the head of Capricorn, $7\frac{1}{2}$° S. West of β Capricorni. Discovered by Mechain, 1780. Resolved by Herschel, and located by him in the 734th order of distances. It is a faint cluster, and only resolved with powerful instruments.

SCUTUM SOBIESKI.

Sobieski's Shield.—A small constellation north of the Bow and Arrow of Sagittarius, only remarkable for its telescopic objects.

TELESCOPIC OBJECTS.

A Large Nebula.—A. R. = 18 h. 11 m. 23 s. Dec. = — 16° 15′ 8″. Just below Sobieski's Shield, discovered by Messier, 1764, and registered as a train of light without stars. Sir W. Herschel describes the object as follows: "A wonderful extensive nebulosity of the milky kind. There are several stars visible, but they can have no connection with the nebulosity, and are doubtless belonging to our own system and are scattered before it." His son says: "The chief peculiarities which I have observed in it are, the resolvable knot in the following portion of the right branch, which is in a considerable degree isolated from the surrounding nebula, strongly suggesting the idea of an absorption of the nebulous matter; and secondly, the much smaller and feebler knot at the north preceding end of the same branch, where the nebula makes a sudden bend at an acute angle." I have examined this object with great attention, and do not find its appearance as figured in the Bedford Catalogue. We are not informed by the author, whether his drawing is original or copied. The horse shoe, or Greek Omega Ω shape given to it by Capt. Smyth, disappears under the 12 inch refractor.

A Great Cluster.—A. R. = 18 h. 09 m. 49 s. Dec. = 18° 27′. Discovered by Messier, 1764, a rich and beautiful object in a dense portion of the Milky Way, northeast 7° from μ Sagittarii. This object, although surrounded by a vast multitude of stars, seems to be separate and distinct from them, and forming a universe of itself. There is a large star near the center, and two predominant ones in the north preceding edge of the cluster. This cluster strikes with more astonishment, as all its stars are distinct and comparatively large. It is well shown by a telescope of moderate power.

A Fine Field of Stars.—A. R. = 18 h. 08 m. 49 s. Dec. — 18° 27′ 05″. Below the left base of the Shield of Sobieski, in a rich portion of the Milky Way.

Discovered by Messier, 1764; and described by him as "a mass of stars—a great nebulosity, of which the light is divided into several parts." The object is readily resolved with powerful instruments.

A Telescopic Double Star.—A. R. = 18 h. 07 m. 37 m. Dec. = — 19° 55′ 05″. A $8\frac{1}{2}$; B 10; magnitude.

Discovered by Sir John Herschel, and described as being placed in a faint nebula, of an elliptical form, and 50″ in diameter. It may be found $1\frac{1}{2}$° northeast of μ Sagittarii.

This Constellation was formed by Hevelius, and lies between Antinoüs and the Serpent's tail. Having no very bright stars, it is difficult to trace. A line drawn from χ in the knee of Antinoüs, to ζ in the left knee of Ophiuchus, passes through several small stars in the Shield.

DIRECTIONS FOR TRACING THE CONSTELLATION ON

MAP NO. XIX.

HERCULES.

Favorably situated for examination in May, June and July.

HERCULES.

HERCULES is represented on the map, invested with the skin of the Nemæan Lion, holding a massy club in his right hand, and the three-headed dog Cerberus in his left.

He occupies a large space in the northern hemisphere, with one foot resting on the head of Draco, on the north, and his head nearly touching that of Ophiuchus, on the south. This constellation extends from 12° to 50° north declination, and its mean right ascension is 255°; consequently its center is on the meridian about the 21st of July.

It is bounded by Draco on the north, Lyra on the east, Ophiuchus or the Serpent-Bearer on the south, and the Serpent and the Crown on the west.

It contains one hundred and thirteen stars, including one of the 2d, or of between the 2d and 3d magnitudes, nine of the 3d magnitude, and nineteen of the 4th. The principal star is *Ras Algethi*, marked α, is situated in the head, about 25° southeast of Corona Borealis. It may be readily known by means of another bright star of equal magnitude, 5° east, or southeast of it, called Ras Alhague. Ras Alhague marks the head of Ophiuchus, and Ras Algethi that of Hercules. These two stars are always seen together, like the bright pairs in Aries, Gemini, the Little Dog, &c. They come to our meridian about the 28th of July, near where

o 2

the sun does, the last of April, or the middle of August.

About midway between Ras Algethi on the southeast, and the Northern Crown on the northwest, may be seen β and γ, two stars of the 3d magnitude, situated in the west shoulder, about 3° apart. The northernmost of these two are called *Rutilicus*.

Those four stars in the shape of a diamond, 8° or 10° southwest of the two in the shoulder of Hercules, are situated in the head of the Serpent.

About 12° E. N. E. of Rutilicus, and 10½° directly north of Ras Algethi, are two stars of the 4th magnitude, in the east shoulder. They may be known by two very minute stars a little above them on the left. The two stars in each shoulder of Hercules, with Ras Algathi in the head, form a regular triangle.

The left, or east arm of Hercules, which grasps the triple-headed monster Cerberus, may be traced by means of three or four stars of the 4th magnitude, situated in a row 3° and 4° apart, extending from the shoulder, in a northeasterly direction. That small cluster, situated in a triangular form, about 14° northeast of Ras Algethi, and 13° east-southeast, of the left shoulder, distinguish the head of Cerberus.

Eighteen or 20° northeast of the Crown, are four stars of the 3d and 4th magnitudes, marked π, η, ζ, ϵ, forming an irregular square, of which the two southern ones are about 4° apart, and in a line 6° or 7° south of the two northern ones, which are nearly 7° apart.

Pi, in the northeast corner, may be known by means of one or two other small stars, close by it, on the east. *Eta*, in the northwest corner, may be known by its being in a row with two smaller stars, extending towards the northwest, and about 4° apart. The stars of the 4th magnitude, just south of the Dragon's head, point out the left foot and ancle of Hercules.

Several other stars, of the 3d and 4th magnitudes, may be traced out in this constellation, by reference to the map.

TELESCOPIC OBJECTS.

Double and Binary Stars.—Ras Algethi or α Herculis, A. R. = 17 h. 07 m. 21 s. Dec. = + 14° 34′ 05″. A beautiful double star on the head of Hercules. Dist. = 4″.5. Pos. 118° 08′. The components are of the magnitudes 3½ and 5½, the largest star orange, the smaller one greenish. There is no reason to believe that these stars are physically united, although the opinion seems to have prevailed among astronomers that such a union would be found to exist among all the colored double stars.

Pos. 117° 36′ Dist. 4″.92 Ep. 1847.62 Mitchel.

γ Herculis.—A. R. = 16 h. 14 m. 53 s. Dec. = + 19° 32′ 00″. A coarse double star on the left arm. Dist. 38″.7. Pos. 242° 03′. A 3½ white, B 10 lilac. No change in distance or position has been detected, except what may be imputed to errors of observation.

ζ Herculis.—A. R. = 16 h. 35 m. 15 s. Dec. = + 31° 53′ 07″. A close *binary* star, over the left hip. A 3d magnitude, B 6 magnitude.
Discovered by Sir W. Herschel, July, 1782.

The companion was subsequently missed by the discoverer, as he believed, in consequence of its being hid by the larger star. He makes the following remark, the interest of which is greatly enhanced by subsequent discoveries: "My observations of this star furnish us with a phenomenon which is new in astronomy; it is *the occultation of one star by another*. This epoch, whatever be the cause of it, will be equally remarkable, whether owing to solar parallax, proper motion, or motion in an orbit, whose plane is nearly coincident with the visual ray.

The star was seen single, up to 1826, when a few measures were made by Strüve. It again became single in 1828, and so continued up to 1832, since which time its double character has been followed. In 1842 the distance had increased to 1″.177, according to Mädler, who computed the elements of the orbit of this swiftly revolving binary system. Its periodic time is about 31 years. On the evening of the 15th of Sept., 1847, the following measures were made with the Cincinnati Refractor.
Pos. 109° 12′ Dist. 1″.078

η Herculis.—A. R. = 16 h. 37 m. 25 s. Dec. = + 39° 13′ 08″, an exceedingly close double star, on the left thigh.
Discovered by Strüve, 1827, and ranked among his closest objects.

It became single, and few if any reliable measures have since been obtained. It has been many times attentively examined by myself, and especially on the evening of the 27th July, 1847, when a power of 1200 was employed. My assistant and myself agreed that the star was slightly elongated nearly along the parallel, but it was very uncertain.

δ Herculis.—A. R. = 17 h. 08 m. 28 s. Dec. + 25° 01′ 09″. A presumed binary star, on the right shoulder. A 4. B 8½ magnitude, on the following evidence:

Pos. = 162° 28′	Dis. 33″ 75	Ep. 1779.61	Herschel.
" 173 42	" 26 .11	" 1829.77	Strüve.
" 175 .01	" 24 .05	" 1839.62	Smyth.

Other double stars will be found by an examination of the star map. Among them κ on the left elbow, ρ on the right thigh, λ on the right arm, and μ in the bend of the left arm, are the brightest.

Great Cluster.—A. R. = 15 h. 35 m. 58 s. Dec. = + 36° 45′ 08″. 3½° from η Herculis, and on the line joining η with ζ.

This object was discovered by Halley in 1714, and was described as a "little patch of light."

It was reëxamined by Messier in 1764, but its true character was still unrevealed. Messier was uncertain whether *any star* was within the nebula. Under the power of Sir William Herschel's great reflector, this object, so faintly seen by Messier, burst into ten thousand stars. It is certainly one of the most magnificent objects in the heavens, and is scarcely ever seen for the first time without exclamations of astonishment. The drawing will be found to agree with the following description, written while the object was under the eye, on the evening of 13th July, 1847, in the Cincinnati Observatory.

"A brilliant cluster, nearly globular. A spur of bright stars runs off to the left, terminating in a sharp point. Then follows in going round the center, from north to east, a dark space; at 90° from the first spur or ray, another is seen less perfectly formed, and more broken at the extremity, containing a pair of double stars near the end. The next 90° pretty well filled with stars out to the circumference, passing through the extremities of the radiations of stars. Then another imperfectly formed spur of stars, containing a pair of double stars midway between the center and the extremity of the spur. The space next following rather vacant, especially near the double star; then follows a bent radiation of bright stars curving to the right, and causing the upper part of the cluster to assume a flattened figure."

This is doubtless one of the many magnificent "island universes," recently revealed by the great instruments of modern times. In 1716 it constituted one of *six* known nebula. In 1766, the number had increased to 103, and is now above 3,000! The clustering of suns at the center of this grand astral system, is greater than is fairly attributable to the optical effect in piercing by the visual ray through a globular cluster of equally distributed stars. There seems to be a condensing power, which has exerted itself to draw the central suns into closer proximity.

A Globular Cluster.—A. R. 17 h. 12 m. 14 s. Dec. = + 43° 18′. 01½° northeast of η Herculis.

Discovered by Messier in 1781, and seen by him as a nebula without stars.

With fine instruments it proves to be a brilliant object, some 7′ or 8′ in diameter, surrounded with many straggling stars. A group of brighter stars forms an inverted figure six around and above the nucleus of the cluster. It is of the same character as the preceding object, but is less extensive, and probably much more remote. Both these clusters may be resolved with a 4 inch glass, and a power of 100 to 200 times. They form fine objects for examination.

A Fine Planetary Nebula.—A. R. = 16 h. 42 m. 23 s. Dec. = + 47° 49′, 4° east by north from τ Herculis.

Discovered in May, 1787.

It is a large, round, pale blue nebula, and has been mistaken for a comet. The size of these objects, in case we regard them as remote as the fixed stars, must be vast beyond comprehension. If an object having a diameter of 95 millions of miles, can only be seen as a mere point of light, what must be the actual dimensions of these planetary nebulæ, presenting as they do, in many instances, measurable diameters of from 03″ to 20″. Such stupendous globes favor the idea that these are vast collections of nebulous matter, slowly condensing under the power of the attraction of gravitation. Such objects as the one now under examination, may present an appearance like that presented by our own sun, when, according to the nebulous theory, its expanded dimensions embraced the grand circumference of the orbit of Neptune. I examined the object on the 1st of August, under very favorable circumstances. The disk-like character which usually is seen on planetary nebulæ, is not well defined on this object. Indeed there is so much nebulous haze surrounding the nucleus, that its appearance is very like a distant cluster. The haze fades away by degrees from the nucleus, and is finally lost.

There are three 7th magnitude stars in the field of view. The nebula is some 7″ or 8″ in diameter.

A Small Planetary Nebula.—A. R. = 16 h. 37 m. 46 s. Dec. = + 24° 05′. This object is bright and well defined. I examined it closely on the 1st of August, 1847. Its disk is about 8″ in diameter, and a little elongated in one direction.

Discovered by Strüve.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. XX.

Cygnus—The Swan.
Lyra—The Harp.
Lacerta—The Lizard.

Favorably situated for examination in August, September and October.

CYGNUS.

The Swan.—This remarkable constellation is situated in the Milky Way, directly east of Lyra, and nearly on the same meridian with the Dolphin. It is represented on outspread wings, flying down the Milky Way, towards the southwest.

The principal stars which mark the wings, the body and the bill of Cygnus, are so arranged, as to form a large and regular *Cross;* the upright piece lying along the Milky Way from northeast to southwest, while the *cross piece*, representing the wings, crosses the other at right angles, from southeast to northwest.

Arided, or *Deneb Cygni*, marked α, in the body of the Swan, is a star of the 2d magnitude, 24° east-northeast of Lyra, and 30° directly north of the Dolphin. It is the most brilliant star in the constellation, and is situated at the upper end of the cross, and comes to the meridian at 9 o'clock, on the 16th of September.

Sad'r, marked γ, is a star of the 3d magnitude, 6° southwest of Deneb, situated exactly in the cross, or where the upright piece intersects the cross piece, and is about 20° east of Lyra.

Delta, the principal star in the west wing, or arm of the cross, is situated northwest of Sad'r, at the distance of little more than 8°, and is of the 4th magnitude. Beyond δ towards the extremity of the wing are two smaller stars about 5° apart, and inclining a little obliquely to the north; the last of which reaches nearly to the first coil of Draco. These stars mark the west wing; the east wing may be traced by means of stars very similarly situated.

Gienah, marked ε, is a star of the 4th magnitude, in the east wing, just as far east of Sad'r in the center of the cross, as δ is west of it. This row of three equal stars, δ, γ, and ε, form the bar of the cross, and are equidistant from each other, being about 8° apart. Beyond ε on the east, at the distance of 6° or 7° there are two other stars, one of the 3d, the other of the 4th magnitude; the last of which marks the extremity of the eastern wing.

The stars in the neck are all too small to be noticed. There is one, however, in the beak of the Swan, at the foot of the cross, called *Albireo*, marked β, which is of the 3d magnitude, and can be seen very plainly. It is about 16° southwest of Sad'r, and about the same distance southeast of Lyra, with which it makes nearly a right angle.

"In the small space between Sad'r and Albireo," says Dr. Herschel, "the stars in the Milky Way seem to be clustering into two separate divisions; each division containing more than *one hundred and sixty-five thousand stars*."

Albireo bears northerly from Altair about 20°. Immediately south and southeast of Albireo, may be seen the Fox and Goose: and about midway between Albireo and Altair, there may be traced a line of four or five minute stars, called the ARROW; the head of which is on the southwest, and can be distinguished by means of two stars situated close together.

According to the British catalogue, this constellation contains eighty-one stars, including one of the 1st and 2d magnitude, six of the 3d, and 12 of the 4th.

TELESCOPIC OBJECTS.

β CYGNI—A. R. = 19 h. 24 m. 16 s. Dec. + 27° 37′ 07″. A large and brilliant colored double star on the bill of the Swan, 13½° southeast of Vega, or α Lyræ. A 3, B 7, magnitude. The principal star is orange, while the companion is a blue, presenting a fine contrast in color. Bradley measured the components in 1755, since which no sensible change has occurred.

Pos. 57° 34′ Dis. 34″.20 Epoch 1755.00

The best position is 54° 40″, as about a mean between those of Herschel, Piazzi, Strüve, South, Dawes, and Smyth, none of whom differ from the others in their results by a whole degree. This star forms one of a group of five in the shape of a cross, and point out the body of the Swan. They may readily be found on the map; β is at the extremity of the longer part of the principal piece in the cross.

δ CYGNI.—A. R. = 19 h. 39 m. 58. Dec. + 44° 44′ 06″. A delicate double star in the middle of the left wing of the Swan, preceding α Cygni by 13°, and on the same parallel. A 3½, pale yellow, B 9, sea-green.

Discovered by Herschel, who made these measures.

Pos. 71° 39′ Dist. 2″.50 Epoch 1783.82.

This star has occasioned no little difficulty, in consequence of the disappearance of the small companion during the years from 1802 up to 1823. Since that time it has been regularly followed. Herschel's distance seems to have been in error, as the following measures will show:

Pos. 40° 39′	Dis. 1″.91	Epoch 1826.55	Strüve,
" 36 42	" 1 .57	" 1831.73	"
" 31 53	" 1 .80	" 1836.52	"

Mädler thinks the stars may perform a revolution about their common center of gravity in about 575 years of our time.

χ CYGNI.—A. R. = 19 h. 40 m. 21 s. Dec. + 33° 21′ 07″. A fine double star on the Swan's neck, 7½° distant from β, in a north-north-east direction. A 5 mag., B. 9, pale blue.

Discovered by Herschel, in 1781.

Since good measures have been obtained, no reliable change in distance or position has been perceived.

Pos. 72° 38′ 05″ Dis. 26″.821 Epoch 1841.49 Mädler.

ψ CYGNI.—A. R. = 19 h. 51 m. 30 s. Dec. + 52° 01′. A double star, between the tip of the Swan's preceding wing and the tail. A 5½, bright white, B 8, lilac.

Pos. 184° 02′ Dis. 3″.05 Epoch 1837.53 Smyth.

No change has been perceived in this beautiful set of stars.

λ CYGNI.—A. R. = 20 h. 41 m. 11 s. Dec. + 35° 54′ 03″, a close, double star, on the Swan's lower or right wing, 5° south-east of γ Cygni. A 5, B 6 mag.

Pos. 130° 00′ Dis. 0″.07 Epoch 1843.71 Strüve.

61 CYGNI.—A. R. = 20 h. 59 m. 43 s. Dec. + 37° 58′. A binary star, on the inner tip of the Swan's right wing. A 5½, B 5 magnitude, both yellow. This system clusters round it more of interest than any other in the heavens. Its binary character, the swiftness of its

proper motion, the determination of its annual parallax and distance, the computation of its mass, and its influence on Mädler's wonderful theory of the *Central Sun*, all combine to make it an object of great importance. Piazzi was the first to announce the rapid and equable proper motion of the components of this system, amounting to 5″.02, in A. R. and 3″.02 in declination. With such a proper motion, and the approximate distance first obtained by MM. Arago and Mathieu, it is easily demonstrated that these two suns are sweeping through space with such an amazing velocity that it exceeds the swiftness of Mercury 60,000 times. Even this astounding result was subsequently found to fall far below the truth. After mounting the great Heliometer of the Köningsburgh Observatory, M. Bessel determined to examine this double star, with a view to the exact determination of its annual parallax. After a long series of elaborate and delicate observations, his efforts were crowned with success, and in 1838 he writes to Sir John F. W. Herschel, as follows:

"I selected among the stars which surround 61 Cygni, two between the 9th and 10th magnitudes, of which one (a) is nearly perpendicular to the line joining the two stars, and the other nearly in the direction of this line. I have measured the distances of these stars from the point which bisects the same distance between the two stars of 61 Cygni. I have commonly repeated the observation *sixteen* times every night."

From these observations, it was discovered that the central point between the components of 61 did not remain at the same distance from the stars of reference, but was more than 0″.6 further from the star (a) in summer than in winter. After proper reduction, the parallax was found to be 0″.3136, with reference to which we record Bessel's remarks, in the following language:

"As the mean error of the annual parallax of 61 Cygni is only ± 0″.0202, and consequently not one-fifteenth of its computed value, and as these comparisons show that the progress of the influence of the parallax, which the observations indicates, follows the theory as nearly as can be expected, considering its smallness, we can no longer doubt that this parallax is sensible. Assuming it 0″ 3136, we find the distance of the star 61 Cygni from the sun 657,700 times the mean distance of the earth from the sun. Light employs 10.3 years to traverse the distance. As the annual proper motion of 61 Cygni amounts to 5″.123 of a great circle, the relative motion of this star and the sun must be considerably more than sixteen semi-diameters of the earth's orbit, and the star must have a constant of aberration of more than 52″. When we shall have succeeded in determining the elements of the motion of both the stars forming the double star round their common center of gravity, we shall be able to determine the sum of their masses. I have attentively considered the preceding observations of the relative positions, but I consider them as yet very inadequate to afford the elements of the orbit. I consider them only sufficient to show that the annual angular motion is somewhere about two-thirds of one degree; and that the distance at the beginning of this century had a minimum of about 15″. We are enabled, hence, to conclude that the time of a revolution is more than 540 years, and that the semi-major axis of the orbit is seen under an angle of more than 15″ of space. If, however, we proceed from these numbers, which are merely limits, we find the sum of the masses of both stars less than half the sun's mass."

These extraordinary details had already rendered this star of extreme interest, when M. Mädler published to the world his great theory of the Central Sun, and refers to the rapid annual proper motion of 61 Cygni, as one of the results deducible from his theory; and further employs its parallax and distance in estimating the distance to Alcyone, in the Pleiades, the star fixed upon as the present center of our Astral system.

Pos.	96° 03′	Dis.	16″.3	Epoch	1839.69	Smyth.
"	101 02	"	17 .3	"	1747.50	Mitchel.

Other double and multiple stars will be found upon the charts.

A Curious Nebula.—A. R = 19 h. 40 m. 35 s. Dec. + 50° 07′ 06″. It is thus described in the Bedford catalogue:

"A very singular object. In my telescope it is small, and somewhat resembles a star out of focus; but both the Herschels agree, on viewing it through their powerful instruments, that it appears to constitute a connecting link between the planetary nebulæ and the nebulous stars. It was discovered September, 1793."

I have repeatedly examined this remarkable object with a 12 inch aperture. Its diameter is about 5″ or 6″, and when the gaze is attentively fixed upon the center, the nebulous matter gradually *fades from the sight*, and *a clear, bright, round star is seen in the center.* This star shows no radiations, such as usually accompany stars viewed with the full opening, but has a clean little disk, such as the telescope shows on other stars with a reduced aperture, under the most favorable circumstances. By throwing off the eye from the center, and looking carelessly over the field of view, the nebula returns in all its beauty, and the central star is no longer seen. This is, doubtless, *optical*, yet it is not easily explicable. That the faint nebula should be better seen *out of the axis* of vision, is easily understood, but this should be true, also, of the central star, and when the nebula brightens up under the eye, the star should increase in brilliancy in the like proportion.

In case we abandon the nebular hypothesis, this object, and one or two others of like character, become utterly inexplicable. If we say that each particle of nebulous light is a sun or star, and that the mass of hazy light, so uniform in its brightness, is but the clustering of millions of suns in a flat annulus, how stupendous must be the size of that lucid point which occupies the center of this wonderful object, and is so distinctly revealed by the telescope? The old idea of a mighty predominant central globe would, on such an hypothesis, seem to be well founded, for it would require millions of nebulous points to constitute a blaze of light equal to this central star. This object is found on the tip of the preceding wing of the Swan, and 5½° north of δ Cygni.

A Loose Small Cluster.—A. R. = 20 h. 18 m. 17 s. Dec. + 37° 59′ 09″.

Discovered by Messier, 1764.

Near the root of the Swan's neck I counted but twenty stars in the field of view, July, 1847, and these were much scattered.

A SMALL CLUSTER, OR RICH FIELD.—A. R. = 21 h. 26 m. 29 s. Dec. + 47° 43′ 08″. It is between the Swan's tail and the Lizard.

Many other clusters and nebulæ will be found on the chart, from which their places in the heavens may be readily found.

LYRA.

THE HARP.—This constellation is distinguished by one of the most brilliant stars in the northern hemisphere. It is situated directly south of the first coil of Draco, between the Swan, on the east, and Hercules, on the west; and, when on the meridian, is almost directly overhead.

It contains twenty-one stars, including one of the 1st magnitude, two of the 3d, and as many of the 4th.

> "There *Lyra*, for the brightness of her stars,
> More than their number, eminent; thrice seven
> She counts, and *one* of these illuminates
> The heavens far round, blazing imperial,
> In the *first* order."

This star, of "the first order, blazing with imperial" luster, is called *Vega*, marked α, and sometimes *Wega*; but more frequently it is called *Lyra*, after the name of the constellation.

There is no possibility of mistaking this star for any other. It is situated 14¾° S. E. of γ Draconis. It may be certainly known by means of two small, yet conspicuous stars, of the 5th and 6th magnitude, situated about 2° apart, on the east of it, and making with it a beautiful little triangle, with the angular point at Lyra.

The northernmost of these two small stars is marked ϵ, and the southern one, ζ. About 2° S. E. of ζ, and in a line with Lyra, is a star of the 4th magnitude, marked δ in the middle of the Harp; and 4° or 5° S. of δ are two stars of the 3d magnitude, about 2° apart, in the garland of the Harp, forming another triangle, whose vertex is in δ. The star on the east is marked γ; that on the west, β. If a line be drawn from γ Draconis through Lyra, and produced 6° farther, it will reach β.

This is a variable star, changing from the 3d to nearly the 5th magnitude in the space of a week. It is supposed to have spots on its surface and to turn on its axis, like our sun.

Gamma comes to the meridian 21 minutes after Lyra, and precisely at the same moment with ϵ, in the tail of the Eagle, 17½° S. of it.

The declination of Lyra is about 38⅔° N.; consequently, when on the meridian, it is but 2° S. of the zenith of Hartford. It culminates at 9 o'clock, about the 13th of August. It is as favorably situated to an observatory at Washington, as Rastaben is to those in the vicinity of London.

Its surpassing brightness has attracted the attention of astronomers in all ages. Manlius, who wrote in the age of Augustus, thus alludes to it:

> "ONE, placed in front above the rest, displays
> A vigorous light, and darts surprising rays."
>
> *Astronomicon*, B. i, p. 15.

TELESCOPIC OBJECTS.

VEGA, OR α LYRA.—A. R. = 18 h. 31 m. 30 s. Dec. = + 38° 38′ 01″, the most brilliant star in the northern hemisphere, attended by a companion of the 11th magnitude, distant 43″.

Pos. 140° Epoch 1843

There is no reason to believe that the relation between these two stars is other than optical. The proper motion of Vega occasions a change in the distance and angle of position of the small companion. Many efforts have been made to obtain the annual parallax of this star. In 1836, M. Strüve concluded the value of the parallax to be 0″.125, with a probable error of 0″.055. This result yields a distance of one and a half millions of times the semidiameter of the earth's orbit. The appearance of α Lyræ in large telescopes is truly magnificent. Before the star enters the field of view, its coming is announced by a dawn of light like that of the early morning, which grows brighter and brighter, until the star, like the sun, enters the field, with a brilliancy which the eye can scarcely bear. By artificial occultation, at the Cincinnati Observatory, no less than *sixteen* minute stars have been counted within the limits of this dawn surrounding Vega.

By the revolution of the pole of the equator around the pole of the ecliptic, in about 10,000 years this brilliant object will become the *pole star.*

The stupendous distance of Vega, as roughly ascertained by Strüve, gave rise to his ingenious theory as to the probable relative positions of the stars of different magnitudes. He considered the stars of the first magnitude distant about two millions of times the radius of the earth's orbit, those of the 6th magnitude *sixteen* millions, those of the 12th *sixty* millions of times the same unit.

β Lyræ.—A. R. = 18° 44′ 09″. Dec. + 33° 10′ 08″, a coarse quadruple star. Of the three components, A is of the 3d, B of the 8th, C of the 8½th, and D of the 9th magnitude. This star is ranked among the variable ones, and has a period of 6 days, 10 hours, 35 minutes, changing from the 3d to the 5th magnitude.

ε and 5 Lyræ.—A. R. = 18 h. 39 m. 02 s. Dec. = + 39° 30′ 03″, a double star. One of the most remarkable objects in the heavens. A of the 5th, B of the 6½th magnitude. The following measures show a retrograde motion.

ε Lyræ. A B

Pos. 33° 55′	Dis. 3″.44	Epoch	1779.83	Herschel.
26 06	3 .03		1831.44	Strüve.
20 25	2 .46		1847.60	Mitchel.

5 Lyræ. C D

Pos. 173° 28′	Dis. 3″.50	Epoch	1779.83	Herschel.
155 10	2 .57		1831.44	Strüve.
149 10	2 .55		1847.60	Mitchel.

There is strong evidence that each of these sets is *binary*. A revolving about B in about 2000 years, while C and D complete their revolution in about half that period.

From the equality of proper motions in the four stars, it is inferred that a physical union may exist among the two pairs, in which case the one pair will perform a revolution about the other in about one million of years!

This star is 1½° northeast of Lyræ, and may be readily divided into two stars with the smallest optical power. The quadruple character is made out with a power of 150 or 200. Several minute points of light are seen between the pairs.

ζ Lyræ.—A. R. =18 h. 39 m. 15 s. Dec. + 37° 26′ 05″, a coarse double star. A 5th, B 5½th magnitude.
Pos. 249° 06′ Dis. 43″.08

ν Lyræ.—A. R. 18 h. 43 m. 48 s. Dec. + 32° 38′ 0″, a coarse quadruple star, just south of *β*, easily divided.

γ Lyræ.—A. R. 19 h. 08 m. 18 s. Dec. = + 28° 52′ 05″, a fine double star; components of the magnitudes 5 and 9.
Pos. 84° 08′ Dis. =28″.3

A Fine Cluster of Small Stars.—A. R. = 19 h. 10 m. 19 s. Dec. = + 29° 54′ 02″.

Discovered by Messier, 1778, but seen by him as a faint nebula.

Resolved by Sir William Herschel in 1784, and located in the 344th order of distances. There is a great clustering about the center, and a rich profusion of stars in the field of view. It may be found on a line joining β Lyræ with β Cygni, about 5½° from the first star. This object is one of the many magnificent astral systems, which are scattered so profusely through the boundless regions of space. Its light requires more than a thousand years to reach our system.

The Annular Nebula—A. R. = 18 h. 47 m. 37 s. Dec. = + 32° 50′, midway between β and γ on the cross-piece of the Lyre.

This wonderful object was first noted by Darquier, in 1779, as a dim planetary disk.

On examination by Sir William Herschel, it proved to be in the form of a perforated ring or annulus. With powerful instruments the dark interior is seen filled with faint gauzy light. The figure is not exactly circular, the diameters being in about the ratio of 4 and 5. Many persons have declared their conviction that they saw the minute stars which it is believed compose this singular object. I have never been able to satisfy myself that it has been fairly resolved. Lord Rosse's great telescope has changed its figure slightly, by finding small filaments of light, extending within and without the ring, in the direction of the larger axis. Herschel estimates the profundity of this object to be of the 950th order. Such an amazing distance absolutely overwhelms the imagination. A thousand times the distance of the nearest fixed stars; Its magnitude must be immense, as its diameter is some 5″ or 6″, even when seen at such an immeasurable distance.

It requires a 4 or 5 inch refractor to yield its figure distinctly to the eye.

It is visible in smaller instruments, but would be mistaken for a star, by any other than a practiced eye.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. XXI.

AQUILA ET ANTINOUS—THE EAGLE AND ANTINOUS.
DELPHINUS—THE DOLPHIN.
TAURUS PONIATOWSKI—PONIATOWSKI'S BULL.
ANSER ET VULPECULA—THE FOX AND GOOSE.

Favorably situated for examination in August, September, and October.

AQUILA ET ANTINOUS.

THE EAGLE AND ANTINOUS.—This double constellation is situated directly south of the Fox and Goose, and between Taurus Poniatowski on the west, and the Dolphin on the east. It contains seventy-one stars, including one of the 1st magnitude, nine of the 3d, and seven of the 4th. It may be readily distinguished by the position and superior brilliancy of its principal star.

Altair, marked α, the principal star in the Eagle, is of the 1st, or between the 1st and 2d magnitudes. It is situated about 14° southwest of Dolphin. It may be known by its being the largest and middle one of the three bright stars which are arranged in a line bearing northwest and southeast. The stars on each side of Altair are of the 3d magnitude, and distant from it about 2°. This row of stars very much resembles that in the guards of the Lesser Bear.

Altair is one of the stars from which the moon's distance is taken for computing longitude at sea. Its mean declination is nearly 8½° north, and when on the meridian, it occupies nearly the same place in the heavens that the sun does at noon on the 12th day of April. It culminates about 6 minutes before 9 o'clock, on the last day of August. It rises *acronycally* about the beginning of June.

Ovid alludes to the rising of this constellation; or, more properly, to that of the principal star, Altair:—

—"Now view the skies,
And you'll behold Jove's hook'd-bill bird arise."
Massey's Fasti.

—"Among thy splendid group
ONE dubious whether of the SECOND RANK,
Or to the FIRST entitled; but whose claim
Seems to deserve the FIRST." *Eudosia.*

The northernmost star in the line, next above Altair, is called *Tarazed*, marked γ. In the wing of the Eagle, there is another row composed of three stars, situated 4° or 5° apart, extending down towards the southwest, the middle one in this line is the smallest, being only of the 4th magnitude, marked μ; the next is of the 4th magnitude, marked *Delta*, and situated 8° southwest of Altair.

As you proceed from δ, there is another line of three stars, of the 4th magnitude, between 5° and 6° apart, extending southerly, but curving a little to the west, which mark the youth Antinoüs. The northern wing of the Eagle is not distinguished by any conspicuous stars.

Zeta of the 3d magnitude, and *Epsilon* of the 4th magnitude, are near the top of the left wing.

From ι to θ, in the wrist of Antinoüs, may be traced a long line of stars, chiefly of the 3d magnitude, whose letter names are θ, η, μ, ζ, and ε. The direction of this line is from southeast to northwest, and its length is about 25°.

Eta is remarkable for its *changeable* appearance. Its greatest brightness continues but 40 hours; it then gradually diminishes for 66 hours, when its luster remains stationary for 30 hours. It then waxes brighter and brighter, until it appears again as a star of the 3d magnitude.

From these phenomena, it is inferred that it not only has spots on its surface, like our sun, but that it also turns on its axis.

Similar phenomena are observed in Algol, β, in the Hare, δ, in Cepheus, and o, in the Whale, and many others.

—"Aquila the next,
Divides the ether with her ardent wing;
Beneath the *Swan*, nor far from *Pegasus*,
POETIC EAGLE."

TELESCOPIC OBJECTS.

A FINE CLUSTER.—A. R.=18 h. 42 m. 32. Dec. 6° 27′ 02″. It precedes the left foot of Antinous, and is on the Shield of Sobieski.

Discovered by Kirch in 1681, and described as "a small obscure spot with a star shining through."

It was resolved by Dr. Durham in 1733. This was one of the six clusters or nebulæ described by Halley in 1716, who ventured to predict that more would be found. This object is figured in the Bedford Catalogue, but is very different from that presented in this volume.

A Triple Star.—A. R. = 18 h. 54 m. 31 s. Dec. — 0° 55′ 09″. Known to Piazzi as double, subdivided by Strüve. A 9, B 9, C 16, magnitude.

Pos.	A B	148° 0′	Dis. 25″.6	Epoch 1838.59	Smyth.
	B C	85 0	2 .0		Estimations.
	B C	76 0	1 .576	1847.60	Mitchel.

The object may be found between the Eagle's wing and the left heel of Antinous.

A Triple Star.—A. R. =19 h. 28 m. 01 s. Dec. = — 10° 46′ 08″. On the right knee of Antinoüs. A 9, B 10, C 12, magnitudes.

Pos.	A B	338° 04′	Dis. 3″.02	Epoch 1835.58	Smyth.
	A C	153 05	8 .00	"	"
	A B	319 04	2 .54	1847.60	Mitchel.
		169 17			

Some suspicion exists with reference to the possible binary character of the set.

A Double Star.—A. R. — 18 h. 57 m. 59 s. Dec. + 6° 18′ 08″, on the edge of the Eagle's wing. A 7½, B 9 magnitude.

Pos.	154° 38′	Dis. 10″.133	Epoch 1831.70	Strüve.
"	152 28	" 9 .492	" 1847.65	Mitchel.

A Small and Loose Cluster.—A. R. 19 h. 08 m. 36 s. Dec. — 1° 11′ 09″, between the lower wing of the Eagle and the thigh of Antinous, consisting of fifteen or twenty stars, with indications of star-dust. Examined 16th July, 1847.

A Stellar Nebula.—A. R. = 19 h. 23 m. 55 s. Dec. + 8° 54′ 01″, on the Eagle's back, 5° east of Altair, or α Aquilæ.

Discovered by Sir W. Herschel, and estimated at the 900th order of distances. Examined on the 16th July, 1847.

The object is very small, brightening at a vertex, and running off in the shape of a fan. Several stars in the field; a bright one above, and one below the nebula. Sir John Herschel says, "It is like a nebula well resolved, and is a curious object."

A Delicate Double Star.—A. R. = 19 h. 35 m. 02 s. Dec. = 8° 00′ 05″, on the Eagle's back, 2° east of Altair, and a little south of the parallel. A 7½, B 9½ magnitude.

Pos. 252° 32′ Dis. 32″.12 Epoch 1825.52 Strüve.

π Aquilæ.—A. R. = 19 h. 41 m. 10 s. Dec. = + 11° 25′ 04″. A close double star, near the northern wing of Aquilæ. A 6, B 7 mag.

Pos.	122° 00′	Dis. 1″.50	Epoch 1831.70	Smyth.
"	123 09	" 1 .20	" 1847.66	Mitchel.

α Aquilæ.—A. R. = 19 h. 42 m. 58 s. Dec. = + 8° 26′ 09″. A first magnitude star, with a 10th magnitude companion, suspected to be physically united,

Pos. 334° 44′	Dis. 143″.40	Epoch 1781 56	Herschel.
" 326 06	" 153 .71	" 1821.85	Strüve.
" 323 06	" 152 .60	" 1834.81	Smith.

The change may be due to a difference of proper motion in the two stars. The annual proper motion of Altair has been fixed at rather more than half a second in A. R., and about one third of a second in declination.

23 Aquilæ.—A. R. = 19 h. 10 m. 24 s. Dec. = + 0° 48′ 00″. A close double star, under the Eagle's southern wing.

Discovered by Herschel, who appears to have made a mistake in entering his measures. His position is 162°, distance 3″.50, epoch 1781.58.

The Bedford Catalogue marks the position more than 180° different, and thinks Herschel wrote *south* for *north*, in recording his observations.

This star was carefully measured on the 4th of August, 1847, and gave these results:

Pos. 12° 09′ Dis. 3″.57.

Bedford Cat. Pos. = 12° 06′ Dis. 3″.1 Epoch 1833.68.

A Double Star.—A. R. = 19 h. 37 m. 21 s. Dec. + 10° 23′ 06″, on the Eagle's head. A 8, B 10 magnitude.

Pos. 278° 18′	Dis. 3″.00	Epoch 1783.60	Herschel.
276 27	3 .99	1825.56	South.
276 30	4 .00	1836.76	Smyth.
276 36	4 .33	1847.72	Mitchel.

The distance between the components seems to be on the increase, while the angle of position remains nearly if not quite the same.

DELPHINUS.

The Dolphin.—This beautiful little cluster of stars is situated 13° or 14° northeast of the Eagle. It consists of eighteen stars, including two of the 3d magnitude, and three of the 4th, but none larger. It is easily distinguished from all others, by means of four principal stars in the head, which are so arranged as to form the figure of a diamond, pointing northeast and southwest. To many, this cluster is known by the name of *Job's Coffin;* but from whom, or from what fancy, it first obtained this appellation, is not known.

There is a star of the 4th magnitude, situated in the body of the Dolphin, about 3° southwest of the Diamond, and marked *Epsilon*. The other four are marked *Alpha*, *Beta*, *Gamma*, and *Delta*. Between these are several smaller stars, too small to be seen in presence of the moon.

The mean declination of the Dolphin is about 15° north. It comes to the meridian the same moment with Deneb Cygni, and about 50 minutes after Altair, on the 16th of September.

"Thee I behold, majestic *Cygnus*,
On the marge dancing of the heavenly sea,
Arion's friend; eighteen thy stars appear—
One telescopic."

TELESCOPIC OBJECTS.

A Planetary Nebula.—A. R. = 20 h. 15 m. 15 s. Dec. 19° 36′ 06″. Between the Dolphin's pectoral fin and the arrow's head.

Discovered by Sir William Herschel, 1782.

This is a large though faint planetary nebula, the surface being evenly illuminated. Sir John Herschel suggests that the minute stars in close proximity to the nebula, may be *satellites.* He remarks "that the enormous magnitude of their bodies, and consequent probable mass (if they be not hollow shells); may give them a gravitating energy, which, however large we may conceive them to be, may yet be capable of retaining in orbits three or four times their own diameter, and in periods of great length, small bodies of stellar character."

Should this suggestion ever be verified, we might be led to attribute some of the anomalous motions (as yet unaccounted for), among some of the fixed stars, to the disturbing influence of an invisible body of this character. In case any such faint body were situated near Sirius, for example, the brilliancy of this star would entirely hide the nebula. Artificial occultation may detect some of these unknown objects.

A Small Cluster.—A. R. = 20 h. 26 m. 21 s. Dec. + 06° 53′, near the Dolphin's tail.

Discovered by Sir W. Herschel, 1785.

It is a mass of small stars, with several larger stars in the field.

β Delphini.—A. R. 20 h. 30 m. 03 s. Dec. + 14° 02′ 06″. A delicate triple star, in the Dolphin's body. A 4, B 12, magnitude. The minute star B, was added to the previously discovered pair by Sir John Herschel. It had escaped his father and Strüve.

Pos. A B	105° 00′	Dis. 15″.0	Epoch 1734.79
A C	341 08	30 .0	"

γ DELPHINI.—A. R. 20 h. 39 m. 15 s. Dec. + 15° 33′ 02″. A beautiful double star on the Dolphin's head. A 4, yellow; B 7, light green. No change has been detected.

Pos. 273° 03′ 00″ Dis. 12″.0 Epoch 1830.

VULPECULA ET ANSER.

THE FOX AND THE GOOSE.—This is a modern constellation, introduced by Hevelius, into a space between the Arrow and the Swan. "I wished," remarked Hevelius, "to place a Fox with a Goose in this space of sky well fitted to it, because such an animal is very cunning, voracious, and fierce. Aquila and Vultur are of the same nature, rapacious and greedy." In 1672, while examining this new constellation, Hevelius discovered a star in the head of the Fox, which he had never before seen. This star remained visible for the space of about two years, after which period it disappeared, and has never since been recognized.

This new constellation has been pretty fairly adopted by astronomers, and may now be said to be pretty firmly fixed in the heavens. Its author counted 27 stars within its limits. The number has been successively increased by later astronomers, until finally, Bode has fixed the places of 126 stars in this small space.

The intrusions or additions of Hevelius to the old constellations have been better received by astronomers than those of any other modern innovator, probably because his constellations were placed where they seemed to be actually required for convenience of reference.

TELESCOPIC OBJECTS.

A DELICATE DOUBLE STAR.—A. R. = 29 h. 00 m. 10 s. Dec + 20° 38′ 07″. Close to the Arrow, under the Fox's shoulder. A 8 B 10, magnitude.

Discovered by Sir James South in 1828.

Pos. 340° 05 Dis. 5″.5 Epoch 1839.70

A Small Double Star.—A. R. 20 h. 15 m. 47 s. Dec. = + 23° 34′ 02″. On the Fox's loins. A 8, B 14, indigo blue.

About a minute of time preceding this object, and 20′ south of it, is a minute close double star, discovered by Strüve, and is No. 2672 of his great catalogue.

Dumb-bell Nebula.—A. R. 19 h. 52 m. 39 s. Dec. 22° 17′ 01″. Discovered by Messier, 1764.

This is one of the large and magnificent nebulæ, located in one of the richest parts of the heavens. As first seen, it resembled two balls joined together like a dumb-bell, or double headed shot, and hence its name. As more powerful instruments have been directed to its examination, its form has become more wonderful and mysterious. The drawing represents this object as seen with the Cincinnati Refractor, July, 1847, at which time it was described while under the eye, as follows:

"The shape of the nebula is an oval or ellipse, whose larger axis occupies four-fifths of the field of view, with a power of 250. The figure imperfect to the left of the lower vertex. The right hand ball of light rather the largest, the round figure being broken by two blunt points. The upper star is seen a little outside the outline. The left hand mass of light takes the same form as that on the right, only the light does not extend up or down quite as far. At each extremity a star is located. The vertices of the great or general outline comparatively faint. Several stars are visible on the nebula. One distinctly seen in the center of the right hand mass of light, one in the center of the principal axis, fainter than the first mentioned; one still more faint midway between these two. Another is seen by glimpses below, and to the right of the one first mentioned. There are besides many stars in the same field of view."

Lord Rosse's great telescope has produced no great change in the figure, while it has revealed more light in the compressed parts of the nebula. Nichol describes it as having "no longer distinctness of completion of form, but a strange mass internally most irregular, clustering apparently around two principal nuclei, or knots of stars, and presenting, where it merges into the dark, the utmost indefiniteness of outline," and yet the figure has an outline quite as well defined as those usually presented in drawings of this object.

This object is doubtless the union of two mighty clusters of myriads of suns, and as the double stars are scattered profusely through space, we occasionally find what may be justly termed *double nebulæ* and *double clusters*. The distance of this object must be absolutely overwhelming, and its dimensions beyond the powers of computation.

It may be picked up on a line joining β Cygni and the Dolphin, and about 7° southeast of the first named star. The angle of position of the line joining the centers of the nebulous masses, is 31° 08′, as measured by Capt. Smyth.

DIRECTIONS FOR TRACING THE CONSTELLATION ON

MAP NO. XXII.

SERPENTARIUS, VEL OPHIUCHUS—THE SERPENT-BEARER.

Favorably situated for examination in June, July, and August.

SERPENTARIUS, VEL OPHIUCUS.

THE SERPENT-BEARER is also called Æsculapius, or the god of medicine. He is represented as a man having both hands clenched in the folds of a prodigious serpent, which is writhing in his grasp.

The constellation occupies a considerable space in the mid heavens, directly south of Hercules, and west of Taurus Poniatowski. Its center is very nearly over the equator, opposite to Orion, and comes to the meridian the 26th of July. It contains seventy-four stars, including one of the 2d magnitude, five of the 3d, and ten of the 4th.

The principal star in Serpentarius is called *Ras Alhague*, marked α. It is of the 2d magnitude, and situated in the head, about 5° east-southeast of Ras Algethi, marked α, in the head of Hercules. Ras Alhague is nearly 13° north of the equinoctial, while *Rho*, in the southern foot, is about 25° south of the equinoctial. These two stars serve to point out the extent of the constellation from north to south. Ras Alhague comes to the meridian on the 28th of July, about 21 minutes after Ras Algethi.

About 10° southwest of Ras Alhague are two small stars, one of the 3d, the other of the 4th magnitude, scarcely more than a degree apart. They distinguish the left or west shoulder. The northern one is marked *Iota*, and the other *Kappa*.

Eleven or twelve degrees south-southeast of Ras Alhague, are two other stars of the 3d magnitude, in the east shoulder, and about 2° apart. The upper one is called *Cheleb*, or β, and the lower one *Gamma*.

These stars in the head and shoulders of Serpentarius form a triangle, with the vertex in Ras Alhague, and pointing towards the northeast.

About 4° east of γ, is a remarkable cluster of four or five stars, in the form of the letter V, with the open part to the north. It very much resembles the Hyades. This beautiful little group marks the face of TAURUS PONIATOWSKI. The solstitial colure passes through the equinoctial about 2° east of the lower star in the vertex of the V. The letter name of this star is k. There is something remarkable in its central position. It is situated almost exactly in the mid heavens, being nearly equidistant from the poles, and midway between the vernal and autumnal equinoxes. It is, however, about one and a third degrees nearer the north than the south pole, and about two degrees nearer the autumnal than the vernal equinox, being about two degrees west of the solstitial colure.

Directly south of the V, at the distance of about 12°, are two very small stars, about 2° apart, situated in the right hand, where it grasps the serpent. About halfway between, and nearly in a line with the two in the hand and the two in the shoulder, is another star of the 3d magnitude, marked *Zeta*, situated in the Serpent, opposite the right elbow. It may be known by means of a minute star just under it.

Marsic, marked λ, in the left arm, is a star of the 4th magnitude, about 10° southwest of ι and κ. About 7° farther in the same direction, are two stars of the 3d magnitude, situated near the hand, and a little more than a degree apart. The upper one of the two, which is about 16° north of Graffias in Scorpio, is called *Yed*, marked δ, the other is marked ϵ. These two stars mark the other point in the folds of the monster where it is grasped by Serpentarius.

The left arm of Serpentarius may be easily traced by means of the two stars in the shoulder, the one (λ) near the elbow, and the other two in the hand; all lying nearly in a line north-northeast, and south-southwest. In the same manner may the right arm be traced, by stars very similarly situated; that is to say, first by the two in the east shoulder, just west of the V, thence 8° in a southerly direction inclining a little to the east, by ζ (known by a little star right under it), and then by the two small ones in the right hand, situated about 6° below ζ.

About 12° from Antares, in an easterly direction, are two stars in the right foot, about 2° apart. The largest and lower of the two, is on the left hand. It is of between the 3d and 4th magnitudes, and marked ρ. There are several other stars in this constellation, of the 3d and 4th magnitudes. They may be traced out from the maps.

TELESCOPIC OBJECTS.

ρ Ophiuchi.—A. R. = 16 h. 16 m. 00 s. Dec. = — 23° 04′ 03″. A fine double star, on the Serpent Bearer's foot. A 5, B 7½ magnitude.

Pos. 3° 01′ Dis. 3″.08 Epoch 1832.38

Discovered by Sir W. Herschel, 1780. There is but little evidence of any physical connection between the components.

λ Ophiuchi, a binary star.—A. R. = 16 h. 22 m. 51 s. Dec. + 2° 20′ 04″. A 4, B 6, magnitude. The following measures are recorded:

Pos. 75° 30′	Dis. 0″.50	Epoch 1783.18	Herschel.
331 48	0 .84	1825.51	Strüve,
356 05	1 .00	1839.67	Smyth.
2 47 8″	1 .29	1841.59	Mädler.
3 42	1 .42	1847.65	Mitchel.

From these observations, it is evident that the stars are revolving about their common center of gravity, in a period of about 120 years.

τ Ophiuchi.—A. R. = 17 h. 54 m. 22 s. Dec. = — 8° 10′ 04″. A very close binary star, on the right hand of Ophiuchus, the closest of Herschel's double stars.

Discovered, April, 1783. A 5, B 6, magnitude. A third star, distant 83″, in the same field of view.

The following measures will exhibit the progressive changes:

Pos. 331° 36′	Dis. elongated	Epoch 1783.27	Herschel.
199 54	0″.436	1836.62	Strüve.
225 36	0 .772	1842.57	Mädler.
229 24	0 .779	1846.51	Mitchel.

Mädler remarks, with reference to this system, as follows: "The periodic time must be about 110 years. The inclination and eccentricity appear to be considerable. The distance was a minimum in 1825, or a short time before. It has regularly increased ever since. It is hoped that observations further south than Derpat may follow this binary system with attention."

Combining all the observations, a shorter period seems to be indicated, perhaps not exceeding 90 years. The yearly change in the angle of position, from 1827 to 1846, amounts to 4° 33′.

70, or *p* Ophiuchi.—A. R. = 17h. 57m. 22s. Dec. = + 2° 32′ 06″ A swiftly revolving binary system. A 4½, B 7, magnitude.

This star has engaged the attention of many distinguished astronomers. The rapidity of its motion excited the notice of its discoverer, and caused the following record: "The alteration of the angle of position that has taken place in the angle of position of this double star is remarkable. October 7, 1779, the stars were exactly in the same parallel, the preceding star being largest. September 24, 1781, it was 9° 14′, n f; and, May 29, 1804, it was 48° 01′, n p; which gives a change of 131° 59′, in 24 years and 254 days." The orbit has been computed by several astronomers; but with the greatest care, recently, by M. Mädler, who has reached the extraordinary conclusion, that these revolving stars are moving under the disturbing influences of some third body, as yet undiscovered.

Mädler's elements are the following:

Periastre passage,	T = 1812.73	
Periodic time,	P = 92.869 years.	
The angle between the maj. axis and line of nodes,	λ =	142° 05′ 08″
Eccentricity,	e =	0.4438
Mean annual angle of motion,	m =	232.584
Angle of position,	☊ =	126 47 02
Inclination of the plane of the orbit,	i =	64 51 04

The following measures will show the changes which have occurred:

Pos. 90° 00′	Dis. 3″.59	Epoch 1779.77	Herschel.
157 36	3 .79	1821.74	Strüve.
137 20	5 .53	1830.57	Dawes.
178 54	6 .44	1837.52	Bessel.
175 26	6 .38	1841.53	Mädler.
120 45	5 .53	1847.55	Mitchel.

The discrepances between computation and observation, ascribed by Mädler to the influence of some unknown disturbing body, have been recently attributed to *aberration*, produced by the motion of the stars in their orbits. This matter is yet in a state of uncertainty.

There are many double stars in this constellation, which will be readily found on the charts, distinguished, as usual, by their round *form*,—all other stars being angular, or star-shaped. Under favorable circumstances, all stars appear round, and disk-like, in large and perfect instruments.

A Rich Globular Cluster.—A. R. = 16 h. 38 m. 56 s. Dec. = — 1° 40′ 03″. This object I have repeatedly examined. It nearly fills the field of view, with a power of 250, its diameter being from 7 to 8 minutes of space. There are three bright stars in the cluster, with many smaller but prominent ones scattered in the field.

Messier discovered it, in 1764, but saw no stars. Herschel locates it at the distance 186. It may be found nearly on the line joining ι and β, and 8¼° distant from the first star. It is represented in the Bedford Catalogue as *greatly condensed* at the center. I find this remark scarcely applicable to its appearance, as seen with the 12 inch refractor. The resolution is complete.

A Cluster of Compressed Stars.—A. R. = 16 h. 48 m. 45 s. Dec. = — 3° 51′ 08″. Discovered by Messier, 1764, and by him described as a beautiful round nebula. It is easily resolved, and, under a full aperture of 12 inches, is a noble object. There are three pretty distinct star-like radiations, running out from the center, and four or five little patches of separate stars in the same field of view. It follows ι Ophiuchi, on the same parallel nearly, and about 8° distant. Sir W Herschel makes its profundity of the 243d order.

A Large Globular Cluster.—A. R. = 17 h. 29 m. 13 s. Dec. = — 3° 00′ 09″. Sir William Herschel describes this object as follows:

"Extremely bright, round, easily resolvable. With a power of 500, I can see the stars. The heavens are pretty rich in stars of a certain size, but they are larger than those in the cluster, and easily to be distinguished from them. This cluster is considerably behind the scattered stars, as some of them are projected on it. From the observations of the 20 feet telescope, which had the power of discerning objects 75.08 times as far as the eye, the profundity of this cluster must be of the 900th order."

This cluster may be found $6\frac{1}{2}^{\circ}$ south by west from γ Ophiuchi, nearly midway from β Scorpii and the tail of Aquila. It is a fine object, large and well defined.

A Large and Easily Resolved Cluster.—A. R. = 17 h. 47 m. 32 s. Dec. = — 18° 58′ 02″, between the left leg of Ophiuchus and the bow of Sagittarius.

Discovered by Messier, 1764. It is on a line northwest from μ Sagittarii, and distant about 5°.

A Close Double Star.—A. R. 16 h. 54 m. 18 s. Dec. = + 8° 41′ 03″. On the right shoulder. A 7, B 8.

Pos. 135° 40′	Dis. 1″.34	Epoch 1830.97	Strüve.
137 00	1 .50	1832.41	Smyth.
146 57	0 .826	1847.70	Mitchel.

These last measures would indicate binary character, and I am confident that they were well made.

36 Ophiuchi.—A. R. = 17 h. 05 m. 29 s. Dec. = — 26° 21′ 05″ A double, or rather, multiple, star, between the left foot and the Scorpion's tail. A $4\frac{1}{2}$, B $6\frac{1}{2}$, magnitude.

Pos. 213° 20	Dis. 5″.32	Epoch 1843.52	Airy.
215 49	4 .27	1847.62	Mitchel.

73 Ophiuchi.—A. R. = 18 h. 01 m. 37 s. Dec. = + 3° 58′ 03″ Between the left shoulder of Ophiuchus and the Serpent's tail. A 6, B $7\frac{1}{2}$, magnitude.

Discovered by Herschel.

Pos. 267° 12′	Dis. 0″.90	Epoch 1783.32	Herschel.
257 37	1 .98	1822.46	Her. & South.
259 44	1 .54	1831.05	Strüve.
255 00	1 .40	1842.00	Smyth.
253 00	1 .274	1847.55	Mitchel.

Here is certainly a binary system. The early measures of Sir W. Herschel, as well as those by Herschel and South, are discordant with the later measures. From 1831 to 1847, a period of 16 years, there has been a change of 6°. The motion is retrograde.

A Double Star.—A. R. = 17 h. 17 m. 21 s. Dec. = + 15° 45′ 04″. Between the heads of Ophiuchus and Hercules. A 7, B 13.

Discovered by Strüve.

Pos. 61° 54′	Dis. 4″.073	Epoch 1830.23	Strüve.
62 33	3 .654	1847.60	Mitchel.

These observations imply fixity in this set.

88 P. XIV, OPHIUCHI.—A. R. = 16 h. 20 m. 10 s. Dec. = — 7° 45′ 09″. A delicate double star, near the right thigh of Ophiuchus. A $7\frac{1}{2}$, B 12. Reckoned a difficult object, from the small size of B.

Pos.	302° 44′	Dis. 4″.687	Epoch 1831.48	Strüve.
	305 00	5 .000	1833.47	Smyth.
	304 14	5 .292	1847.70	L. M.

There is strong evidence of fixity in these measures, and there is little reason to believe that these stars are otherwise than optically related.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. XXIII.

PEGASUS—THE FLYING HORSE.
EQUULUS—THE HORSE'S HEAD.

Favorably situated for examination in September, October, November and December.

PEGASUS.

THE FLYING HORSE.—This constellation is represented in an inverted posture, with wings. It occupies a large space in the heavens, between the Swan, the Dolphin and the Eagle, on the west; and the Northern Fish and Andromeda, on the east. Its mean right ascension is 340°, or, it is situated 20° W. of the *prime meridian.* It extends from the equinoctial N. 35°. Its mean length, E. and W., is about 40°, and it is six weeks in passing our meridian, viz. from the 1st of October to the 10th of November.

We see but a part of Pegasus, the rest of the animal being, as the poets imagined, hid in the clouds.

It is readily distinguished from all other constellations by means of four remarkable stars, about 15° apart, forming the figure of a square, called the *square of Pegasus.* The two western stars in this square come to the meridian about the 23d of

October, and are about 13° apart. The northern one, which is the brightest of three triangular stars in the martingale, is of the second magnitude, and is called *Scheat*, marked β. Its declination is 26¾° N. *Markab*, marked α, also of the second magnitude, situated in the head of the wing, is 13° S. of Scheat, and passes the meridian 11 minutes after it.

The two stars which form the eastern side of the square, come to the meridian about an hour after those in the western. The northern one has already been described as *Alpheratz*, or α, in the head of Andromeda; but it also belongs to this constellation, and is 14° E. of Scheat. 14° S. of Alpheratz, is *Algenib*, a Persei (see Map No. I), the last star in the wing, situated 6½° E. of Markab.

Algenib, in Pegasus, *Alpheratz,* in Andromeda, and *Caph,* in Cassiopeia, are situated on the *prime meridian,* and point out its direction through the pole. For this reason, they are sometimes called the *three guides.* They form an arc of that great circle in the heavens from which the distances of all the heavenly bodies are measured. It is an arc of the equinoctial colure, which passes through the vernal equinox, and which the sun crosses about the 21st of March. It is, in astronomy, what the meridian of Greenwich is in geography. If the sun, or a planet, or a star, be said to have so many degrees of right ascension, it means that the sun or planet has *ascended* so many degrees from this prime meridian.

Enif, marked ε, sometimes called *Enir,* is a star of the third magnitude, in the nose of Pegasus, about 20° W. S. W. of Markab, and half way between it and the Dolphin. About one-third of the distance from Markab towards Enif, but a little to the S. there is a star of the 3d magnitude, in the neck, whose letter name is Zeta. The loose cluster directly S. of a line joining Enif and Zeta, forms the head of Pegasus.

In this constellation, there are eighty-nine stars visible to the naked eye, of which three are of the second magnitude, and three of the third.

TELESCOPIC OBJECTS.

A Double Star.—A. R. = 21 h. 14 m. 41 s. Dec. = 19° 07′ 04″, between the head of Pegasus and the hind legs of the Fox. A 4, considered variable; B 9, magnitude.

Pos. 310° 08′ Dis. 36″.4 Epoch 1333.95

Although no sensible change has yet heen discovered in this set, a common proper motion would indicate some physical union.

A Large and Brilliant Cluster.—A. R. = 21 h. 22 m. 13 s. Dec. = + 11° 27′ 04″, between the mouths of Pegasus and Equulus.

Discovered by Meraldi, 1745, and described by him as "a nebulous star, quite bright, and composed of several stars."

It was fully resolved by Sir William Herschel, 1783, and placed by him in the 243d order of distances. This object is greatly condensed at the center, and has many radiations.

There is a great condensation at the center, and even a brilliant nucleus, around which the stars are scattered in rich profusion for a distance of about 2′ in diameter. Beyond this the cluster is less rich in stars. The space preceding the cluster is nearly vacant. The following space is tolerably well filled with stars.

A Small Double Star.—A. R. = 22 h. 06 m 37 s. Dec. = + 16° 24′ 02″, between the head and legs of Pegasus. A 7½, B 10½. The first yellow, the second green.

Discovered by Strüve.

Pos. 316° 24′	Dis. 7″.63	Epoch 1828.95	Strüve.
331 29	8 .03	1847.65	Mitchel.

This is certainly a binary system.

37 Pegasi.—A. R. = 22 h. 21 m. 53 s. Dec. = + 03° 37′ 03″, a binary star on the mane and near the head of Pegasus. A 6, B 7½.

Discovered by Strüve.

Pos. 112° 36′	Dis. 1″.36	Epoch 1831.12	Struve.
118 54	1 .10	1839,66	Smyth.
121 46	0 .98	1847.70	Mitchel.

Here is strong evidence of binary character, as the angular velocity has been on the increase, and the distance is certainly diminishing.

55 H. I., Pegasi.—A. R. = 22 h. 56 m. 58 s. Dec. = + 11° 27′ 09″, an elongated nebula in the Horse's mane.

Discovered by Herschel in 1784.

This is an exceedingly faint and difficult object. I examined it carefully in September, 1847, and although it was readily found, it required very close gazing to make any thing out of it. It stretches between two stars, the upper one of which is not touched by the nebulous matter. A minute telescopic star just precedes the upper extremity of the nebulous matter, which seems to have been overlooked by preceding observers. There is something of a glow at the center after long gazing, and under a side glance.

This object is thought to be a flat ring seen obliquely. It is one of the most difficult objects in the heavens, and requires a powerful instrument for satisfactory examination.

EQUULUS, VEL EQUI SECTIO.

THE LITTLE HORSE, OR THE HORSE'S HEAD.—This Asterism, or small cluster of stars, is situated about 7° west of Enif, in the head of Pegasus, and about halfway between it and the Dolphin. It is on the meridian at 8 o'clock on the 11th of October. It contains ten stars, of which the two principal are only of the 4th magnitude. These may be readily distinguished by means of the long irregular square which they form. The two in the nose, are much nearer together than the two in the eyes; the former being 1° apart, and the latter 2½°. Those in the nose are uppermost, being 4° north of those in the eyes. This figure also is in an *inverted* position. These four stars are situated 10° or 12° southeast of the diamond in the Dolphin's head. Both of these clusters are noticeable on account of their figure rather than their brilliancy.

TELESCOPIC OBJECTS.

376 P. XX, EQUULEI.—A. R. = 20 h. 47 m. 40 s. Dec. = + 03° 55′ 06″, a close double star between the Horse's head and the bow of Antinous. A 6, B 8, magnitude.

Discovered by Strüve.

Pos. 289° 10′	Dis. 1″.8	Epoch	1829.48	Strüve.
287 45	" 1 .874		1847.65	Mitchel.

These measures may possibly indicate a slow retrograde motion, a change of 2° about in 18 years. This would give an *annus magnus* to the system of more than 4000 years.

ε EQUULEI.—A. R. = 20 h. 51 m. 05 s. Dec. = 03° 41′ 01″, a delicate triple star, preceding the Horse's forehead. A 5½, B 7½.

Discovered to be double by Herschel; subdivided by Strüve.

Pos. A B	290° 00′	Dis. 0″.50	Epoch	1838.83	Smyth.
	288 06	0 .574		1847.60	Mitchel.
A C	84 21	9 .37		1780.59	Herschel.
	79 21	12 .37		1823.58	Her. & South.
	78 01	11 .20		1838.83	Smyth.
	76 25	11 .08		1847.60	Mitchel.

These measures determine the binary character of A and C, which is likewise rendered more certain by the equality of their proper motion.

Here we are presented with a magnificent system. Three suns revolving about their common center of gravity, and sweeping, together with their trains of planets and comets, through the regions of space.

λ Equulei.—A. R. = 20 h. 54 m. 19 s. Dec. = + 06° 33′ 03″. A fine double star preceding the Horse's nose. A 6, B 6½, magnitude. Discovered by Strüve.

Pos. 225° 36′	Dis. 2″.6	Epoch 1833.72	Smyth.
227 42	1 .9	1847.60	Mitchel.

These observations are not sufficient to determine the binary character.

DIRECTIONS FOR TRACING THE CONSTELLATIONS ON

MAP NO. XXIV.

AQUARIUS—THE WATER-BEARER.
CAPRICORNUS—THE GOAT.

Favorably situated for examination in September, October, November and December.

AQUARIUS.

THE WATER-BEARER.—This constellation is represented by the figure of a man, pouring out water from an urn. It is situated in the Zodiac, immediately south of the equinoctial, and bounded by the Little Horse, Pegasus, and the Western Fish on the north, the Whale on the east, the southern Fish on the south, and the Goat on the west. It is now the 12th in order, or last of the Zodiacal constellations; and is the name of the 11th *sign* in the ecliptic. Its mean declination is 14° south, and its mean right ascension 335°, or 22 hours, 20 min.; it being 1 hour and 40 min. west of the equinoctial colure; its center is, therefore, on the meridian the 15th of October.

It contains one hundred and eight stars; of which the four largest are all of the 3d magnitude.

"His head, his shoulders, and his lucid breast,
Glisten with stars; and where his urn inclines,
Rivers of light brighten the wat'ry track."

The northeastern limit of Aquarius may be readily distinguished by means of three stars of the 4th, and one of the 5th magnitude, in the hand and handle of the urn, so placed as to form the letter Y, very plainly to be seen, 15° southeast of *Enif*, or ε Equulei, or 18° S. S. W. of Markab, in Pegasus; making with the two latter nearly a right angle.

About 4½° west of this figure is *El Melik*, marked α, a star of the 3d magnitude, in the east shoulder, and the principal one in this constellation. 10° southwest of α, is another star of the same magnitude, situated in the west shoulder, called *Sad es Saud*, marked β.

Ancha, marked θ, of the 5th magnitude, is in the right side, 8° south of α. 9° east of θ, is another star of the 4th magnitude, whose letter name is *Lambda*.

Scheat, marked δ, of the 3d magnitude, lying below the knee, is situated 8½° south of λ; and 14 south of δ, the brilliant star Fomalhaut, of the 1st magnitude, terminates the cascade in the mouth of the Southern Fish. This star is common to both these constsellations, and is one of those from which the lunar distance is computed for ascertaining the longitude at sea. It culminates at 9 o'clock on the 22d of October.

Fomalhaut, Deneb Kaitos, and Alpha in the head of Phœnix, make a large triangle, whose vertex is in Deneb Kaitos. Those two stars of the 4th magnitude, situated 4° south of β, and nearly the same distance from θ, are in the tail of Capricorn. They are about 2° apart. The western one is called *Deneb Algedi*.

The rest of the stars in the cascade are quite small; they may be traced from the letter Y, in the urn, in a southeasterly direction towards the tail of Cetus, from which the cascade suddenly bends off near δ, in an opposite course, and finally disappears in the mouth of the Southern Fish, 30° south of Y.

TELESCOPIC OBJECTS.

4 Aquarii.—A. R. = 20 h. 42 m. 57 s. Dec. = — 6° 13′ 02″. A close binary star, between Aquarius and Equuleus. A 6, yellow; B 8, purple.

Discovered by Sir W. Herschel.

The following measures are the only ones which I have been able to find.

Pos. 351° 30′	Dis. 00″.30	Epoch 1782.68	Herschel.
25 07	00 .81	1825.59	Strüve.
24 36	00 .6	1841.51	Mädler.

A Planetary Nebula.—A. R. = 20 h. 55 m. 27 s. Dec. = — 11° 59′ 00″. In the middle of the Scarf of Aquarius. It may be found nearly on the parallel of α Capricorni, and 12° east of it.

Discovered by Sir William Herschel in 1782.

Its diameter amounts to no less than 20″. The surface evenly tinted and of a delicate pale blue. Its disk is comparatively well defined, and the tint resembles that of Uranus and Neptune. Its distance must be equal to that of the fixed stars, as it has no annual parallax. Its diameter, therefore, cannot be less than three thousand millions of miles. I have frequently examined this wonderful object, and on the 9th of September, 1847, found its diameter to be about 9″ or 10″. The upper part is wanting in roundness, giving it the appearance of an obtuse crescent.

12 Aquarii.—A. R. = 20 h. 55 m. 37 s. Dec. = — 06° 27′ 00″. A close double star in the space between the Scarf of Aquarius, and the head of Equuleus. A 5½, white; B 8½, light blue.

Discovered by Strüve.

Pos. 189° 36′	Dis. 02″.66	Epoch 1831.31	Strüve.
191 00	02 .80	1831.82	Smyth.
191 30	08 .23	1847.63	Mitchel.

There is something extraordinary about this star. The distance obtained by my measures is nearly four times as great as that in the books; and the star B instead of being of the 8½ magnitude, is certainly as low as the 15th. I satisfied myself of this by turning the instrument on β Aquarii, whose companion is of the 15th magnitude. The star may be variable, but the increase of distance is unaccountable.

β Aquarii—A. R. = 21 h. 23 m. 07. Dec. = — 06° 16′ 00″, on the right shoulder of Aquarius. A 3, yellow; B 15, blue.

Discovered by Herschel, who gave the

Pos. 325° 48′	Dis. uncertain.	Epoch 1782	
370 00	02″.00	1833	Smyth.

This last is a mere estimation.

29 Aquarii.—A. R. = 21 h. 53 m. 41 s. Dec. = — 17° 43′ 09″. A beautiful double star on the tail of Capricorn. A 6, B 8, magnitude.

Pos. 243° 34′	Dis. 04″.50	Epoch 1823.19	Strüve.
242 08	04 .466	1847.70	Mitchel.

These measures decide the character of the star. The components must be optically united.

A Fine Globular Cluster.—A. R. = 21 h. 25 m. 10 s. Dec. = — 01° 32′ 01″, on the neck of Aquarius.

Discovered by Meraldi in 1746, more than a hundred years ago, and among the first known nebula.

It was fully resolved by Sir William Herschel, with his 40 feet reflector, when the entire mass was found to consist of myriads of stars, ranged in a compressed form, and closely clustering about the center. He estimated its profundity as of the 243d order. This object was examined with a power of 250, and a 12 inch aperture, on the evening of the 9th of September, 1845, and described as follows. The cluster enters the field in great beauty. It is distinctly resolved, though the stars composing it are very minute, with great condensation at and around the center. The diameter of the brightest portion is about 2′ by estimation. A coarse double star follows above the cluster. Several bright stars in the field. There are no radiations of stars, the mass being nearly globular, with an outline somewhat broken.

41 Aquarii.—A. R. = 22 h. 05 m. 27 s. Dec. = — 21° 51′ 00″. A double star between the Water-bearer and the Southern Fish. A 6, B 8½, magnitude.

Discovered by Herschel, but registered by him without measures.

Pos. 120° 42′	Dis. 05″.17	Epoch 1823.78	Herschel & South.
120 22	04 .326	1847.70	Mitchel & L.

An interval of 24 years between these measures, indicates the fixity of the components of these stars.

ζ Aquarii.—A. R. = 22 h. 20 m. 35 s. Dec. = — 00° 50′ 02″. A binary star on the left wrist of Aquarius. A 4, B 4½, magnitudes.

Discovered by Herschel in 1779, and found to be binary as early as 1804.

Pos. 355° 14′	Dis. 03″.525	Epoch 1830.98	Bessel.
352 43	03 .389	1836.05	Strüve.
352 10	04 .123	1841.48	Mädler.
348 54	02 .70	1842.59	Smyth.
346 42	03 .948	1847.70	Mitchel.

The last measures but one seem to be in error both in distance and position. Mädler thinks the period of this system may be about 780 years. My own measures were confirmed by those of my assistant, the readings agreeing admirably with each other.

A Close Double Star.—A. R. = 22 h. 34 m. 40 s. Dec. = — 9° 08′ 08″. near the stream issuing from the vase and near the vase's mouth. A 7, B 8½, magnitude.

Discovered by Herschel.

Pos. 311° 12′	Dis. 03″.00	Epoch 1782.74	Herschel.
317 22	——	1821.92	Strüve.
313 08	02 .7	1838.67	Smyth.
314 35	01 .82	1847.70	Mitchel.

The distance in this set seems to be diminishing, and a revolution in an orbit whose plane is nearly coincident with the visual ray appears probable.

τ Aquarii.—A. R. = 22 h. 39 m. 13 s. Dec. = — 14° 53′ 09″. Above the left knee of Aquarius. A 6, B 9½, magnitude.

Discovered by Herschel in 1782.

A Triple Star.—A. R. = 22 h. 39 m. 35 s. Dec. = —5° 03′ 05″. In the mouth of the vase. A 7½, B 8, C 9, magnitude.

94 Aquarii.—A. R. = 23 h. 10 m. 41 s. Dec. = — 14° 19′ 07. In the space between the stream and the left knee of Aquarius. A 6, B 8½, magnitude.

Discovered by Piazzi.

107 Aquarii.—A. R. = 23 h. 37 m. 42 s. Dec. = — 19° 34′ 01″. Near the center of the stream flowing from the urn. A 6, white; B 7½, blue.

Discovered by Herschel in 1780.

CAPRICORNUS.

The Goat.—This is the tenth sign, and eleventh constellation, in the order of the Zodiac, and is situated south of the Dolphin, and next east of Sagittarius. Its mean declination is 20° south, and its mean right ascension, 310°. It is therefore on the meridian about the 18th of September. It is to be observed that the first point of the *sign* Capricorn, *not the constellation*, marks the southern tropic, or winter solstice. The sun, therefore, arrives at this point of its orbit the 21st of December, but does not reach the *constellation* of Capricorn until the 16th of January.

The sun having now attained its utmost declination south, after remaining a few days apparently stationary, begins once more to retrace its progress northwardly, affording to the wintry latitudes of the north, a grateful presage of returning spring.

At the period of the winter solstice, the sun is vertical to the tropic of Capricorn, and the southern hemisphere enjoys the same light and heat which the northern hemisphere enjoys on the 21st of June, when the sun is vertical to the tropic of Cancer. It is at this period, mid day at the south pole, and midnight at the north pole.

The whole number of stars in this constellation is fifty one; none of which are very conspicuous. The three largest are only of the 3d magnitude. There is an equal number of the 4th.

The head of Capricorn may be recognized by means of two stars of the 3d magnitude, situated a little more than 2° apart, called *Giedi*, marked α, and *Dabih*, marked β. They are 28° from the Dolphin, in a southerly direction.

Giedi is the most northern star of the two, and is double. If a line be drawn from Lyra through Altair, and produced about 23° farther, it will point out the head of Capricorn. These two stars come to the meridian the 9th of September, a few minutes after Sad'r, in Cygnus.

A few other stars, of inferior note, may be traced out by reference to the maps.

The *sign* of the Goat was called by the ancient orientalists the "Southern Gate of the Sun," as Cancer was denominated the "Northern gate." The ten stars in the *sign* Capricorn, known to the ancients by the name of the "Tower of Gad," are probably now in the constellation Aquarius.

TELESCOPIC OBJECTS.

α^2 Capricorni.—A. R. 20 h. 09 m. 10 s. Dec. = — 13° 02′ 01″. A double star of special interest. A 3, B 16, magnitude.

This minute point of light was regarded by Sir John Herschel as possibly a *satellite, and shining by a reflected light.* On a cursory review of this region of the heavens, in September, 1846, I turned the instrument on α^2 Capricorni in the presence of nearly a full moon, and instantly detected the small companion. I had forgotten that this was one of the stars to which Herschel had directed attention, and supposed that I might be the first who had seen the companion. A slight reference to the catalogues showed this to be wrong. It does not appear on Strüve's great catalogue, neither do I find any measures, except a few of position by Sir John Herschel, in Sept. 26th, 1832.

Pos. 141° 42′ No distance given.

I measured this object in August and September, 1846, and found
Pos. 144° 11′ Dis. 6″.36

This star is really *quintuple*, the most distant star of the five being 373″ from the principal.

ρ Capricorni.—A. R. = 20 h. 19 m. 44 s. Dec. = — 18° 20′ 02″. A double star with a distant companion. A 5, B 9, C 7½, mag.

Pos. A B	176° 42′	Dis. 3″.8	Epoch 1830.73	Smyth.
	176 56	3 .094	1847.70	Mitchel.

This object is found on the right ear of Capricorn.

σ 2 Capricorni.—A. R. = 20 h. 20 m. 43 s. Dec. = — 19° 06′ 04″. A double star between the right ear and the eye of the animal. A 6, B 7, magnitude.

Pos. 239° 09′ Dis. 21″.8 Epoch 1832.59 Smyth.

The connexion is merely optical, as seems to be shown by the recorded measures.

A Globular Cluster.—A. R. = 20 h. 44 m. 39 s. Dec. = — 13° 07′ 06″. Between Aquarius and the neck of Capricorn, due east of α Capricorni.

Discovered by Messier in 1780.

Resolved by Herschel, and pronounced to be in the 243d order of distances, and described by him as follows. "It is a cluster of stars of a round figure, but the very faint stars on the outside of globular clusters are generally a little dispersed, so as to deviate from a perfectly circular form. . . . There are many stars in the same field of view, but they are of several magnitudes, totally different from the excessively small ones which compose the cluster. It is not possible to form an idea of the number of stars which form such a cluster, but we are not to estimate them by hundreds."

A Fine Cluster.—A. R. = 21 h. 31 m. 16 s. Dec. = — 23° 52′ 04″. Under the caudal fin of the animal.

Discovered by Messier in 1764, who saw it circular, and without *any star*.

Resolved by Sir William Herschel in 1783. Examined by myself in September, 1847, and described as follows. An irregular cluster. It brightens at the center, and throws out three distinct radiations of stars. All are directed downwards, or towards the north. An 8th magnitude star precedes the cluster by about 5 minutes of arc. Several stars are in the field.

In closing our review of the constellations, we present the following table, exhibiting, for each month in the year, the rising, culminating, and setting of the visible constellations.

JANUARY.

Rising.	*Culminating.*	*Setting.*
Hercules,	Draco,	Cygnus, *the neck,*
Corona Borealis,	Polaris,	Pegasus, *the hoofs,*
Boötes,	Camelopardus,	Pisces, *the ribbon,*
Virgo,	Lynx,	Cetus, *the body,*
Crater,	Gemini,	Eridanus,
Pyxis Nautica,	Monoceros,	Columba Noachi.
Argo Navis.	Canis Major.	

Rising.	*Culminating.*	*Setting.*
	FEBRUARY.	
Lyra,	Cygnus, *the tail,*	Pisces, *the N. fish,*
Hercules,—*shoulders,*	Cepheus, *the knee,*	Aries, *the fore legs,*
Serpens, *the head,*	Polaris,	Cetus, *the head,*
Virgo, *the feet,*	Ursa Major, *fore legs,*	Eridanus,
Corvus,	Lynx, *the tail,*	Lepus, *the fore legs,*
Hydra, *the lower fold.*	Cancer, *the claws,*	Canis Maj., *hind legs*
	Hydra, *the head.*	Argo Navis.
	MARCH.	
Cygnus,—*foll'g wing*	Lacerta, *the back,*	Andromeda, *the body,*
Lyra,	Cepheus, *the arm,*	Triangulum,
Hercules, *the head,*	Polaris,	Musca,
Ophiuchus, *the head,*	Ursa Major, *hind legs,*	Taurus,
Serpens, *the middle,*	Leo, *the flank,*	Orion,
Libra,	Crater,	Canis Maj., *the head.*
Hydra, *the tail.*	Hydra, *the body.*	
	APRIL.	
Lacerta,	Andromeda, *the body,*	Andromeda, *the feet,*
Vulpecula,	Cassiopeia, *the waist,*	Medusa's Head,
Sagitta,	Polaris,	Taurus, *the horns,*
Aquila, *the tail,*	Ursa Major, *the tail,*	Orion, *the head,*
Ophiuchus, *the knees,*	Canis Venatici, *the fore legs,*	Monoceros,
Scorpio, *the head,*	Vergo, *the waist,*	Pyxis Nautica,
Centaurus, *the head.*	Corvus, *the tail.*	Antlia Pneumatica.
	MAY.	
Andromeda, *the feet,*	Perseus, *the head,*	Auriga, *the legs,*
Pegasus, *the fore legs,*	Cassiopeia, *the feet,*	Gemini, *the legs,*
Equulus, *the nose,*	Polaris,	Cancer,
Delphinus, *the body,*	Draco, *the tail,*	Hydra, *the heart,*
Antinous,	Boötes, *the body,*	Crater,
Scorpio, *the tail;*	Libra,	Corvus,
Lupus, *the head.*	Centaurus, *the hand.*	Centaurus, *the head.*
	JUNE.	
Medusa's Head,	Auriga, *the kids,*	Gemini, *the head,*
Triangulum,	Camelopardus,	Cancer, *the body,*
Pisces, *the N. fish,*	Polaris,	Leo, *the fore legs,*
Pegasus, *the wing,*	Draco, *the body,*	Sex. Uraniæ,
Aquarius, *shoulders,*	Hercules, *the back,*	Corvus,
Capricornus, *the head,*	Ophiuchus,	Hydra, *the tail,*
Sagittarius, *the body.*	Scorpio, *the tail.*	Lupus, *the head.*

JULY.

Rising.	*Culminating.*	*Setting*
Auriga, *the waist*,	Lynx, *the head*,	Lynx, *the hind legs*,
Perseus, *the feet*,	Camelopardus, *neck*,	Leo Minor, *the legs*,
Musca,	Polaris,	Leo, *the tail*,
Aries, *the head*,	Draco,	Virgo, *the shoulders*,
Pisces, *the tail*,	Lyra,	Libra,
Aquarius, *the legs*,	Scutum Sobieski,	Scorpio, *the body*.
Sagittarius, *the hips*.	Sagittarius, *the head*.	

AUGUST.

Lynx, *the body*,	Ursa Maj., *the head*,	Leo Minor,
Gemini, *Castor's arm*	Polaris,	Coma Bernices,
Auriga, *the knees*,	Cepheus, *the sceptre*,	Boötes, *the feet*,
Taurus, *the head*,	Cygnus, *the body*,	Libra,
Cetus, *the mouth*,	Vulpecula,	Serpentarius,—*legs*,
Pisces Australis,	Delphinus,	Sagittarius, *the waist*.
Microscopium.	Capricornus, *neck*.	

SEPTEMBER.

Leo Minor, *the head*,	Ursa Major, *the body*,	Canes Venatici,
Lynx, *the hind legs*,	Draco, *the tail*,	Boötes, *the knees*,
Gemini, *the bodies*,	Polaris,	Serpens, *the head*,
Orion, *the shoulders*,	Cepheus, *head & body*	Ophiuchus, *the waist*,
Eridanus,	Pegasus, *the chest*,	Scutum Sobieski,
Cetus, *the legs*,	Aquarius,	Sagittarius,
App. Sculptoris.	Piscis Australis.	Piscis Australis.

OCTOBER.

Leo Minor, *the body*,	Ursa Major, *the tail*,	Boötes, *the shoulders*,
Cancer, *the body*,	Draco, *the tail*,	Corona Borealis,
Canis Minor,—*head*,	Polaris,	Hercules, *shoulders*,
Monoceros, *the neck*,	Cassiopeia, *the head*,	Ophiuchus, *the head*,
Orion, *the leg*,	Andromeda, *breast*,	Taurus Poniatowski,
Lepus, *the head*,	Pisces, *the ribbon*,	Capricornus, *the head*
Fornax Chemica.	Cetus, *the tail*.	Piscis Australis.

NOVEMBER.

Canes Venatici,	Draco, *the last coil*,	Hercules, *the legs*,
Leo, *the body*,	Ursa Minor, *the head*,	Cerberus, et Ramus,
Hydra, *the head*,	Polaris,	Sagitta,
Monoceros,	Perseus, *shoulders*,	Aquila, *the body*,
Canis Major,—*head*,	Aries, *the body*	Equulus,
Lepus, *body*,	Cetus, *the mouth*,	Aquarius,
Eridanus,	Fornax Chemica.	App. Sculptoris.

DECEMBER.

Rising.	*Culminating.*	*Setting.*
Boötes,	Draco, *the middle,*	Lyra,
Coma Bernices,	Ursa Minor, *haunch,*	Cygnus, *the head,*
Leo,	Polaris,	Vulpecula, *the legs,*
Sextans Uraniæ,	Camelopardus, *body,*	Pegasus, *the head,*
Hydra,	Taurus, *the head.*	Pisces, *the W. fish,*
Argo Navis,	Eridanus.	Cetus, *the tail,*
Canis Major.		Fornax Chemica.

N. B. The risings are taken along the horizon, from the north, round by the east, to the south; the *culminations* from the north horizon, over the pole and zenith, and thence down to the south horizon; the settings are reckoned from the north, by the west, round to the south. Polaris, though not always precisely on the meridian, is included in every month as a guide.

CHAPTER V.

THE FIXED STARS — THEIR DISTANCE AND MOTIONS — THE MILKY WAY — CLUSTERS — NEBULÆ.

Thus far in our examination of the constellations, the stars have only been considered in their relations of apparent magnitude or brilliancy and position. Their absolute magnitudes, distances, motions, and positions, have not been regarded, except as notices have been taken of a few among the telescopic objects. We propose to consider, now, the discoveries which have recently been made in sidereal astronomy; and we commence with the *parallax* of the fixed stars.

Definition.—The *parallax* of any heavenly body is the apparent change in its position, occasioned by any real change in the position of the spectator.

Thus, if a person on the earth's surface should, while looking at the moon just rising, be suddenly transported down to the earth's center, as he descended the moon would appear to ascend, and this seeming change in the moon's place is a *parallactic* change. The rapid apparent whirling of the forest trees, occasioned by flying swiftly past them in a coach or car, is a similar effect from a like cause. More accurately, the moon's parallax is the angle formed at the moon's center by two lines, the one drawn tangent to the earth's surface, the other drawn to the earth's center. In case a spectator could be transported to the moon's center, at the instant she is rising above the horizon of any place, and could see the earth's radius drawn to this place, the two visual rays drawn to the extremities of this radius would form an angle at the eye of the observer, which would be the moon's *horizontal parallax*. These two visual rays and the earth's radius form a triangle, in which one side (the earth's radius) is known, the angles are readily measured, and hence it becomes possible to learn the value of the remaining sides, either of which measures the moon's distance from the earth.

When, therefore, the parallax of any heavenly body is once determined, it is an easy matter to compute its distance. If one could be transported to a fixed star, when rising, and view from this position the earth's radius, the angle formed by the visual rays drawn to the two extremities of this radius, would be the star's parallax. In consequence of the vast distance of the fixed stars, this angle, thus formed, is too minute to be appreciable; no instruments devised by human skill or science, can be constructed so as to measure so minute a quantity. We are, therefore, obliged to resort to some other method to determine the parallax of the stars. In case the earth were at rest in the universe, there would be no possibility of ever measuring the distance of the fixed stars; but its annual sweep around the sun in an orbit whose radius is about ninety-five millions of miles, transports the astronomer through space, around an orbit whose longest diameter is nearly two hundred millions of miles. If, now, the observer send up a visual ray to a fixed star, when at one extremity of the longest diameter of the earth's orbit, and at the end of six months, when he shall have reached the other extremity of the same diameter, he send up a second visual ray to the same star, these two rays will stand upon a base whose length is nearly *two hundred millions* of miles, and the angle formed by them, at the fixed star, will be its *parallax.* To render this plainer, suppose a globe bright as the sun, and of a diameter equal to that of the earth's orbit, filled this grand circumference; the apparent diameter of such a globe, as seen from the star in question, would be its parallax.

At first view it would seem almost impossible to remove a spectator so far, that a globe of two hundred millions of miles in diameter should shrink to a point almost imperceptible, or that by distance its diameter should become scarcely perceptible with the most powerful instruments; yet this is literally true. To measure this apparent diameter, or to obtain the angle of the visual rays drawn from its extremities to a fixed star, has for more than a hundred years, called into requisition the highest skill, genius, and patience, ever put forth by man. The problem is no less than the determination of the distances of the fixed stars. Three processes have been employed in the investigation of this problem, each of which, and its results, we shall succinctly present.

1. Bradley's Method.—Suppose a telescope bolted firmly to a solid rock, hewn in the form of a vertical shaft. This rock is absolutely immovable, and the telescope is so situated that its axis is exactly vertical, and is perfectly immovable. In the focus of the eye piece of the telescope, let two spider's webs of the finest texture cross each other at right angles, and by their intersection form a point of almost mathematical minuteness, precisely in the axis of the telescope. With this instrument the astronomer is prepared to commence his research of the parallax of a fixed star. Placing his eye to the instrument, he watches until a certain fixed star enters the field of the telescope. It actually threads like a bead of light, the spider's line drawn parallel to the direction of the star's apparent diurnal motion; it moves on, and the precise instant when it reaches the intersection of the spider's lines is noted and recorded, and thus the first observation is terminated. Now the telescope, its rocky base,

and the observer, are carried by the earth round the sun, and in case any change in the apparent place of the star is occasioned by the revolution of the earth in its orbit, as the star is watched night after night, throughout the year, it will be found slowly to leave the spider's line which it at first threaded, and gradually to move either towards the north or south, while it fails to cross the center at the exact instant of time first recorded. A little thought will render clear this beautiful and simple method of ascertaining the parallax, or apparent change of place, of the fixed stars. Such was mainly the method employed by Bradley, the great English astronomer. Its accuracy was wonderful, but it failed to detect any parallax. Buried in depths almost infinite, the stars escaped from this first scrutinizing process.

2. Herschel's Method.—In the outset of Herschel's explorations among the double stars, he believed them to be only optically related; that is, their proximity was occasioned by the fact that the visual ray drawn by the observer to one star, passed almost exactly through the other. In case then, two stars could be found very near to each other, of whose components the one was about double the other, it was fair to conclude that the smaller was twice as remote as the larger, and if properly chosen, the annual revolution of the earth in its orbit could hardly fail to cause some change in the relative positions of these stars. Suppose that on the first of January the small star is seen exactly on the right of the large one; at the end of three months it is seen a little to the south and just under the large one; at the close of six months it is to the left; at the end of nine months it is just above and a little north of the large star; and when the year closes it comes to resume its primitive position. In case such changes are repeated from year to year, and in the same order, and in many double stars, it is impossible to resist the conclusion that it is a parallactic change. Such was the method practised by Herschel, but an unforeseen discovery destroyed the hope of detecting the parallax in this way. It was found that these double stars, in many instances at least, were not merely related by accidental position, but were actually united by the great law of universal gravitation; one star or sun revolving about the other, or rather the two suns revolving about their common center of gravity. The actual motions became, in this way, so involved in these only apparent or parallactic motions, that to distinguish them became impossible.

These methods then failed to reveal the distances of the stars, although they were not without results of the most important character, and without a knowledge of which, the problem of the parallax could never have been resolved. Bradley discovered the *nutation* and *aberration* of the fixed stars, while Herschel reached the grand fact of the *binary* character of the double stars.

3. Bessel's Method.—After mounting a large telescope called a *heliometer*, peculiarly adapted for the micrometrical measure of large as well as minute distances among the double stars, Bessel selected 61 Cygni as the object on which he determined to concentrate his entire attention. This double star was eligibly situated in the heavens, and could be observed nearly every month in the year. It had near it several minute stars which could be used as points of reference, and finally the rapidity of its proper motion indicated its probable nearness to our sun and system. Bessel selected two minute stars as points of reference, the one in a line nearly perpendicular to the middle point of the line joining the components of 61 Cygni, the other in the direction of this line. With the heliometer he measured the distance of the middle point of the line joining the components of 61 Cygni, from each of the points of reference, 16 times each night, and finally detected a change in these distanoes which seemed to depend on the orbitual revolution of the earth. Some three years of observation confirmed the accuracy of the first results, and gave the parallax of this double star equal to 0″.3480, or only about three-tenths of one second of arc, so that if a globe of 100,000,000 of miles in diameter, could be seen from this fixed star, its diameter would not appear greater than about the six-thousandth part of the sun's apparent diameter. The parallax once obtained, the distance is readily deduced, and is found to be 657,700 times greater than the earth's distance from the sun, or so remote that the light of the star only reaches us after a journey of more than *ten years*, although it flies at the rate of twelve millions of miles in every minute.

The distance of the double star being known, observation gives us about 540 years for the period in which the components revolve around their common center of gravity in an orbit whose diameter is about ninety times the diameter of the earth's orbit, while the amount of matter in these two stars is a little less than half that contained in our sun.

Since Bessel determined the parallax of 61 Cygni, other astronomers have pursued the investigation with success. The following have been deduced by the Russian astronomer M. Peters, and announced in a recent work by M. Strüve, of Pulkova.

Absolute	parallax of	61 Cygni	+ 00″.349.
"	"	α Lyræ	+ 00 .103.
"	"	Polaris	+ 00 .067.
"	"	Groombridge No. 1830	+ 00 .226.
"	"	α Aurigæ or Copella	+ 00 .046.
"	"	ι Ursa Major	+ 00 .133.
"	"	α Boötis, Arcturis	+ 00 .127.

From the table it is readily seen that 61 Cygni is the nearest of all the fixed stars whose distances have been discovered.

M. Strüve, by a beautiful train of reasoning, deduces the relative distances of the stars of the various magnitudes, from the 1st to the 6th magnitude inclusive, and finds them to constitute a geometrical progression whose common ratio is 1 divided by the square root of 2. Calling the distance of the 6th magnitude stars 10.000 he finds

Magnitude.	Dist. determined.	Computed.
6	1.0000	1 0000.
5	0.6998	0.7071.
4	0.5001	0.5000.
3	0.3602	0.3536.
2	0.2413	0.2500.
1	0.1424	0.1768.

It will be seen that the numbers in the two columns scarcely differ, except in the case of stars of the 1st magnitude, and here too few exist to furnish M. Strüve with the requisite data for his computations. So that this most curious law of distances would seem to be founded in nature. Every even term is half the preceding even one, and the same of every odd term.

If it were now possible to determine the absolute mean distance of the stars of any one magnitude, the real distances of all other magnitudes would readily be derived from this remarkable law. This has been approximately accomplished by the Russian astronomers. From the actual parallax of about thirty stars of the 2d magnitude, the value of the mean parallax of all the stars of that magnitude has been derived, and we are now able to present the following table:

App. mag.	Parallax.	Distance (radius of Earth's orbit = 1).	Time for light to come in years.
1	00″.166	1,216.000	19.6
2	00 .098	2,111.000	33.3
3	00 .065	3,151.000	49.7
4	00 .047	4,375.000	69.0
5	00 .034	6,121.000	96.6
6	00 .024	8,746.000	137.9
7	00 .014	14,230.000	224.5
8	00 .008	24,490.000	386.3
9	00 .006	37,200.000	586 5
Herschel's smallest stars	00 .00092	224,500.000	3541.0

It is not pretended that these results are absolute. These values are only approximate, but the errors are comparatively small; and show to us clearly, the vastness of the universe of God.

Having learned in this way the distances of the fixed stars, the inquiry arises, how are these objects distributed throughout space? Are they scattered indifferently in all directions, and at distances nearly equal from each other, or is their distribution governed by any attainable law? The bright circle of light called the *Milky Way*, which sweeps round the entire circuit of the heavens, and which to the naked eye appears only faintly luminous, when examined with the telescope, is found to consist of millions of stars, crowded and condensed together with the most extraordinary richness and profusion. Herschel conceived the idea of measuring the depths to which the stars extended in the Milky Way, and by reaching out beyond its extreme limits, ascertaining the figure which would be formed by cutting this vast bed of stars by a plane drawn perpendicularly to its surface. It is manifest, that if the stars are all at equal distances, and finite in number, that wherever the stratum extends deepest into space, there will we be enabled to count the greatest number of stars in the field of a given telescope. And indeed, the number counted in any two directions, by the same telescope, will give the relative depth to which the stars extend at these two points. Such was Herschel's plan of *sounding* the Milky Way, and of learning its figure. With the full power of his twenty feet reflecting telescope, he thought it possible to pierce through even the deepest portions of the Milky Way, and to send the visual ray far beyond. This idea, so long maintained by the followers of Herschel, has recently been attacked by Prof. Strüve of Pulkova, who maintains that it was abandoned by Herschel himself in his later papers. Sir John Herschel does not accord with the views of Strüve, but maintains the original opinions of his father.

From the investigations of the two Herschels, the vast stratum of stars, called the Milky Way, appears to be arranged under the figure of a flat ring, whose thickness is small when compared with its diameter. The central parts of the ring are not so thickly strewn with stars as the outer portions or circumference. The rim is divided into two branches, or streams of stars. which diverge from each other for a certain distance, but finally re-unite and flow on together. The two Herschels have made a sufficient number of observations to determine the figure cut from this bed of stars by a plane perpendicular to its surface, and cutting across the portion where the two streams are most distant from each other. There are portions of the Milky Way included in this section, in which it is said, the stars extend so deep in space that the series in a right line, from the sun out to the extreme limit, cannot number less than *five hundred* stars, each as remote from the other as 61 Cygni is from our sun. In case we admit this statement, there are stars belonging to our

Milky Way so widely separated, that their light will require more than ten thousand years to pass from one to the other, or to sweep across the longest diameter of this mighty universe of stars.

If Strüve's idea of the absolute *unfathomable* character of the Milky Way be adopted, it only increases the sweep or range of suns and systems, grouping them into subordinate clusterings, and uniting them into one unbounded, immeasurable, innumerable, whole. In whatever way, under whatever aspect, we contemplate this vast constellation of constellations; this magnificent cluster of clusters; the number, distance, magnitude, and brilliancy, of its components, cannot fail to fill the mind with wonder and astonishment.

Admitting that the telescopic vision sweeps beyond the limits of the Milky Way, it may be asked, what does the eye encounter in these remote regions? Many objects lying in these far distant portions of space, have already been noticed among the telescopic objects of the different constellations. These are the *clusters and nebulæ.* By a careful examination of these wonderful objects, Herschel finally reached the conclusion, that all the clusters, and many of the nebulæ, were immense aggregations of stars, forming separate universes, as extensive and rich as the Milky Way itself. He even ventured to attempt the measure of the relative depths of these remote objects. His method is simple, and may be readily comprehended. The naked eye can discern stars of the sixth magnitude, or those twelve times as remote as Sirius, the largest and brightest star in the heavens. In case the pupil of the eye could be expanded to twice its present dimensions, it could then penetrate twice as deep into space as it now can, or would see Sirius if it were removed backward twenty-four times deeper into space. Now, although the pupil of the eye cannot literally be expanded to twice or thrice its present size, the telescope comes in to accomplish precisely the same effects; and admitting that an object glass permits all the light which falls on it to pass through, its power to penetrate space will be in the ratio of its surface to that of the pupil of the human eye. By covering a large object glass with circular coverings, pierced with apertures of one inch, two inches, &c., diameter in the center, we may give to it, at pleasure, different space penetrating powers. Fixing the relation of these to the eye, we are prepared to examine any object, and determine, approximately, its distance. Suppose a nebula is seen faintly visible, with three inches of aperture to the object glass. We expand the aperture to four inches—it appears brighter, but no stars are seen. We increase the aperture to five inches, the nebula grows still brighter at the center, but as yet no point-like stars are visible; a farther increase to six inches, however, shows the object to consist of millions of minute stars, just rendered visible to the eye. Now the length of the visual ray of the telescope, compared with that of the unaided eye, is readily determined; and knowing this, we learn, approximately, the distance of this cluster of stars. In this way Sir W. Herschel determined the profundity of all the principal clusters.

Some of the nebulæ could not, by any space penetrating power of his great telescopes, be resolved into stars. Their shapes were irregular, and their outlines ill defined. Some were easily visible to the naked eye, and yet no telescopic power could resolve them into stars. Others were found to contain occasional stars, with centers of more or less condensed light; finally, stars were found surrounded by a nebulous haze of vast extent, whose center was occupied by the star. Examining and comparing all these phenomena, Herschel finally reached the conclusion, that while vast numbers of apparent nebulæ were real clusters of stars, yet there were some in which the material composing them was a kind of luminous mist, like that forming the tails of comets. He conjectured that this chaotic matter might possibly furnish the material out of which, by condensation, stars might be forming. The nebulous stars, as well as the planetary nebula, seemed to accord very perfectly with this hypothesis. Double and triple nebulæ were found, from which the double and triple stars might eventually spring, and thus grew up, imperceptibly, the outlines of a magnificent theory, a sort of sublime cosmogony of the universe. These speculations, enlarged by La Place, as we shall see hereafter, were made to render an account of the sun and planets, and the peculiar arrangement of the solar system. The nebular theory, as it is termed, had for a long while its ardent supporters, and if not absolutely adopted by distinguished astronomers, at least, it was received by them with no inconsiderable favor. The resolution of the nebula in Orion, by Lord Rosse, and by Prof. Bond, of Cambridge, has in some degree shaken the faith of some in this remarkable hypothesis, while it is justly remarked, that Herschel only adopted it after the resolution of hundreds of nebulæ.

In case we abandon the idea of chaotic matter existing in space, and adopt the notion that the filmy, almost spiritual, objects, which barely stain with light the blue of the heavens, are immense congeries of stars, it only expands our knowledge of the illimitable extent of the universe of God. Some of these objects are so remote, that a hundred thousand years must roll away, before the light which they emit could traverse the distance by which we are separated from them.

Many of the clusters of stars appear under globular forms, and from the manifest condensation about their centers, seem to indicate the existence of some active energetic power, like gravitation, which is exerting its influence on the individual stars of these grand systems. The extension of the law of universal gravitation to the region of the fixed stars, was long believed, before it could be positively demonstrated. By the discovery of the binary or revolving suns, this conjecture became a positive fact. In a large number of instances, the orbits described by these bodies around their common centers of gravity, have been computed according to the law of gravitation, and in every instance the predictions have been verified. That stars do attract each other is now positively demonstrated, and the law of attraction is the inverse ratio of the square of the distance, or that of gravitation. If two or three stars, grouped together, are subject to this law, it is reasonable to conclude that larger collections, such as the Pleiades, or Coma Berenices, may be under the controlling power of the same force. And if this be true, why not extend its operation to the mighty cluster of clusters, the Milky Way itself.

This has been done recently by M. Mädler, of Dorpat, Russia, and he thinks he has determined, approximately, the center of the stratum of stars, or the *astral system*, composing the Milky Way. By comparing the absolute places of the fixed stars, at intervals of one or two hundred years, it is found that a large number of them are in motion, and with an appreciable velocity. This is not merely apparent, but in many instances must be absolute change of place in space. Some stars are moving very swiftly, and exhibit their progressive changes in a few months; while others, again, move with such extreme slowness, that even hundreds of years are necessary to render their change appreciable. It seems quite as reasonable to suppose that these complex and involved motions of the distant stars, should be governed by some simple and beautiful law, as that the planets, whose apparent motions were far more complicated, should be reduced to order and simplicity. This great task of unraveling the complicated phenomena of the proper motion of the fixed stars, has been attempted by the Russian astronomer.

It had long been conjectured that the analogy existing in the solar system would hold among the systems of stars. And that as the sun was vastly larger than his revolving planets, and as each primary planet was much superior to his revolving moons, so there might exist in space some *mighty central sun*, whose vast proportions would far exceed all the stars subject to its controlling influence. This analogy was broken by the discovery of the binary stars. Here we find many instances in which the components are exactly equal in magnitude; others, again in which the one is slightly superior to the other; in short, all possible relations of magnitude. This does not interfere with the stability and perfection of the systems. The components revolve about their common center of gravity as though it were filled with a mass of solid matter. Mädler rejects the idea, then, of the existence of any vast central globe, and argues that in case it existed, it would be impossible to prevent its discovery. The stars in its immediate neighborhood would reveal it by their swifter proper motions; as no such motions are known, or have ever been discovered, it is fair to conclude that none such exist, and that there is no central predominant orb, but a mere *center of gravity*, which should be the object of research. By a train of beautiful and ingenious reasoning, he demonstrates to his own satisfaction, that this central point must be found somewhere in the Milky Way, and finally locates it in the cluster called the *Pleiades*. The brightest star of the group is called Alcyone or η Tauri, and the star at present occupies the center of gravity of the grand stratum of stars composing the *Milky Way*, and around this center all the millions of stars are slowly performing their vast revolutions.

Among these our own sun and system is comprehended, and Mädler estimates that one single revolution of the sun around this distant center requires *no less than eighteen millions two hundred thousand* years. The distance of Alcyone from our sun cannot be less than thirty-four millions of times the radius of the earth's orbit. Should the universe endure so long, at the end of nine or ten millions of years, the revolution of the sun in its orbit will cause a total change in the apparent relative positions of the fixed stars. The present well known constellations will have been swept from the heavens, and new configurations of the stars will have usurped the places of the old ones. No new creation will cause these changes, but they come as the inevitable consequences of the motion of the solar system. When we shall have examined the construction of this system, we shall then present the evidences of its swift translation through space.

It seems next to impossible to estimate the number of fixed stars constituting our own astral system. Catalogues of all the brighter stars have been formed. Some of these contain even fifty thousand stars, observed by a single individual. Strüve reaches the conclusion, that Herschel's twenty feet reflector could reach no less than twenty millions three hundred and seventy-four thousand stars in the celestial sphere; and it has been estimated that the forty feet instrument would carry the number up to at least *one hundred millions*.

Let it be remembered that these stars compose but a single astral system, or as the Germans term them "Island Universes." More than *three thousand* of these systems have been discovered, some of them doubtless far more magnificent and populous in stars than our own; and yet all these innumerable worlds and suns and systems have been brought within the range of human vision by the powers of the telescope.

The power of this instrument in penetrating space is only equaled by its extraordinary capacity to divide space. The micrometer of the great refractors now in use, can divide a single inch into eighty thousand equal parts! and should two close fixed stars commence to separate from each other by so small a quantity that even three millions of years would be required for a complete revolution in the heavens, these delicate instruments would detect the motion in a single year. With such instruments, it is not wonderful that human genius dares the most difficult researches.

CHAPTER VI.

GENERAL PHENOMENA OF THE SOLAR SYSTEM.

Thus far our attention has been directed to the phenomena of the sidereal heavens. The names, positions, and relative magnitudes of the stars; their changes of light, proper motion, and physical association into systems of greater or less complexity, have been considered and explained. The mind has penetrated but a comparatively short distance in its investigations of the starry heavens, and a great many mysterious points yet remain to be explained. The phenomena of the new stars, of the lost stars, of the nebulous stars, of the variable stars, all remain without satisfactory explanation. Advances are constantly making; and reasoning from past success, the future may be looked forward to with the highest anticipations. The confirmation or disproof of the nebular theory, and of Mäedler's hypothesis of the central sun, will probably in a few years reward the diligent and unremitting researches of philosophers.

Leaving the region of the fixed stars, there now remain to be considered certain other celestial bodies, all of which, from their remarkable appearance and changes, and some of them from their intimate connection with the comfort, convenience, and even existence of man, must have always attracted especial observation, and been objects of the most intense contemplation and the deepest interest. Most of these bodies are situated within the limits of the Zodiac. The most important of them are, the Sun, so superior to all the heavenly bodies for its apparent magnitude, for the light and heat which it imparts, for the marked effects of its changes of position in regard to the Earth; and the Moon, so conspicuous among the bodies which give light by night, and from her soft and silvery brightness, so pleasing to behold; remarkable not only for changes of position, but for the varied phases or appearances which she presents, as she waxes from her crescent form through all her different stages of increase to a full orb, and wanes back again to her former distinguished figure.

The partial or total obscuration of these two bodies, which sometimes occurs,—darkness taking place even at mid-day, and the face of night, before lighted up by the moon's beams, being suddenly shaded by their absence,—have always been among the most striking astronomical phenomena; and so powerful in their influence upon the beholders, as to fill them with perplexity and fear. If we observe these two bodies, we shall find, that, besides their apparent diurnal motion across the heavens, they exhibit other phenomena, which must be the effect of motion. The sun, during one part of the year, will be seen to rise every day further and further toward the north, to continue longer and longer above the horizon, to be more and more elevated at mid-day, until he arrives at a certain limit; and then, during the other part, the order is entirely reversed. The moon sometimes is not seen at all; and then, when she first becomes visible, appears in the west, not far from the setting sun, with a slender crescent form. Every night she appears at a greater distance from the setting sun, increasing in size, until at length she is found in the east, just as the sun is sinking below the horizon in the west.

The sun, if his motions be attentively observed, will be found to have another motion, opposite to his apparent diurnal motion from east to west. This may be perceived distinctly, if we notice, on any clear evening, any bright star, which is first visible after sunset, near the place where he sunk below the horizon. The following evening, the star will not be visible on account of the approach of the sun, and all the stars on the east of it will be successively eclipsed by his rays, until he shall have made a complete apparent revolution in the heavens. These are the most obvious phenomena exhibited by these two bodies.

There are, also, situated within the limits of the zodiac, certain other bodies, which, at first view, and on a superficial examination, are scarcely distinguishable from the fixed stars. But observed more attentively, they will be seen to shine with a milder and steadier light; and besides being carried round with the stars, in the apparent revolution of the great celestial concave, they will seem to change their places in the concave itself. Sometimes they are stationary; sometimes they appear to be moving from west to east, and sometimes to be going back again from east to west; being seen at sunset sometimes in the east, and sometimes in the west, and always apparently changing their position with regard to the earth, each other, and the other heavenly bodies. From their wandering, as it were, in this manner, through the heavens, they were called by the Greeks πλανηται, planets, which signifies *wanderers*.

There also sometimes appear in the heavens bodies of a very extraordinary aspect, which continue visible for a considerable period, and then disappear from our view; and nothing more is seen of them, it may be for years, when they again present themselves, and take their place among the bodies of the celestial sphere. They are distinguished from the planets by a dull and cloudy appearance, and by a train of light. As they approach the sun, however, their faint and nebulous light becomes more and more brilliant, and their train increases in length, until they arrive at their nearest point of approximation, when they shine with their greatest brilliancy. As they recede from the sun, they gradually lose their splendor, resume their faint and nebulous appearance, and their train diminishes, until they entirely disappear. They have no well defined figure; they seem to move in every possible direction, and are found in every part of the heavens. From their train, they were called by the Greeks κομηται, comets, which signifies having long hair.

The causes of these various phenomena must have early constituted a very natural subject of inquiry. Accordingly, we shall find, if we examine the history of the science, that in very early times there were many speculations upon this subject, and that different theories were adopted to account for these celestial appearances.

The Egyptians, Chaldeans, Indians, and Chinese, early possessed many astronomical facts, many observations of important phenomena, and many rules and methods of astronomical calculation; and it has been imagined, that they had the ruins of a great system of astronomical science, which, in the earliest ages of the world, had been carried to a great degree of perfection, and that, while the principles and explanations of the phenomena were lost, the isolated, unconnected facts, rules of calculation, and phenomena themselves remained. Thus, the Chinese, who, it is generally agreed, possess the oldest authentic observations on record, have recorded in their annals a conjunction of five planets at the same time, which happened 2461 years before Christ, or 100 years before the flood. By mathematical calculation, it is ascertained that this conjunction really occurred at that time. The first observation of a solar eclipse, of which the world has any knowledge, was made by the Chinese, 2128 years before Christ, or 220 years after the deluge. It seems, also, that the Chinese understood the method of calculating eclipses; for, it is said that the emperor was so irritated against the great officers of state for neglecting to predict the eclipse, that he caused them to be put to death.* The astronomical epoch of the Chinese, according to Bailly, commenced with Fohi, their first emperor, who flourished 2952 years before the Christian era, or about 350 years before the deluge.

If it be asked how the knowledge of this antediluvian astronomy was preserved and transmitted, it is said that the columns on which it was registered have survived the deluge, and that those of Egypt are only copies, which have become originals, now that the others have been forgotten. The Indians, also, profess to have many celestial observations of a very early date. The Chaldeans have been justly celebrated in all ages for their astronomical observations. When Alexander took Baby-

* It is well known that the Chinese have, from time immemorial, considered their solar eclipses and conjunctions of the planets as prognostics of importance to the empire, and that they have been predicted as a matter of state policy.

lon, his preceptor, Callisthenes, found a series of Chaldean observations, made in that city, and extending back, with little interruption, through a period of 1903 years preceding that event. This would carry us back to at least 2234 years before the birth of Christ, or to about the time of the dispersion of mankind by the confusion of tongues. Though it be conceded that, upon this whole period in the history of the science, the obscurity of very remote antiquity must necessarily rest, still it will remain evident that the phenomena of the heavenly bodies had been observed with great attention, and had been a subject of no ordinary interest.

But, however numerous or important were the observations of oriental antiquity, they were never reduced to the shape and symmetry of a regular system.

The Greeks, in all probability, derived many notions in regard to this science, and many facts and observations, from Egypt, the great fountain of ancient learning and wisdom, and many were the speculations and hypotheses of their philosophers. In the fabulous period of Grecian history, Atlas, Hercules, Linus and Orpheus, are mentioned as persons distinguished for their knowledge of astronomy, and for the improvements which they made in the science. But, in regard to this period, little is known with certainty, and it must be *considered*, as it is termed, *fabulous.*

The first of the Greek philosophers who taught astronomy, was Thales, of Miletus. He flourished about 640 years before the Christian era. Then followed Anaximander, Anaximenes, Anaxagoras, Pythagoras, Plato. Some of the doctrines maintained by these philosophers were—that the earth was round; that it had two motions, a diurnal motion on its axis, and an annual motion around the sun; that the sun was a globe of fire; that the moon received her light from the sun; that she was habitable, contained mountains, seas, &c.; that her eclipses were caused by the earth's shadow; that the planets were not designed merely to adorn our heavens; that they were worlds of themselves; and that the fixed stars were centers of distant systems. Some of them, however, maintained that the earth was flat; and others, that, though round, it was at rest in the center of the universe.

When that distinguished school of philosophy was established at Alexandria, in Egypt, by the munificence of the sovereigns to whom that portion of Alexander's empire had fallen, astronomy received a new impulse. It was now, in the second century after Christ, that the first complete system or treatise of astronomy, of which we have any knowledge, was formed. All before had been unconnected and incomplete. Ptolemy, with the opinions of all antiquity, and of all the philosophers who had preceded him, spread out before him, composed a work, in thirteen books, called the Μεγαλη Ευνταξις, or Great System. Rejecting the doctrine of Pythagoras, who taught that the sun was the center of the universe, and that the earth had a diurnal mo tion on its axis and an annual motion around the sun, as contrary to the evidence of the senses, Ptolemy endeavored to account for the celestial phenomena, by supposing the earth to be the center of the universe, and all the heavenly bodies to revolve around it. He seems to have entertained an idea, in regard to the supposition that the earth revolved on its axis, similar to one which some entertain even at the present day. "If," says he, "there were any motion of the earth, common to it and all other heavenly bodies, it would certainly precede them all, by the excess of its mass being so great; and animals, and a certain portion of heavy bodies, would be left behind, riding upon the air, and the earth itself would very soon be completely carried out of the heavens."

In explaining the celestial phenomena, however, upon his hypothesis, he met with a difficulty in the apparently stationary attitude and retrograde motions which he saw the planets sometimes have. To explain this, however, he supposed the planets to revolve in small circles, which he called epicycles, which were, at the same time, carried around the earth in larger circles, which he called differents, or carrying circles. In following out his theory, and applying it to the explanation of different phenomena, it became necessary to add new epicycles, and to have recourse to other expedients, until the system became unwieldy, cumbrous, and complicated. This theory, although astronomical observations continued to be made, and some distinguished astronomers appeared from time to time, was the prevailing theory until the middle of the fifteenth century. It was not, however, *always* received with implicit confidence; nor were its difficulties *always* entirely unappreciated.

Alphonso X, king of Castile, who flourished in the thirteenth century, when contemplating the doctrine of the epicycles, exclaimed, "were the universe thus constructed, if the Deity had called me to his counsels at the creation of the world, I could have given him good advice." He did not, however, mean any impiety or irreverence, except what was directed against the system of Ptolemy.

About the middle of the fifteenth century, Copernicus, a native of Thorn, in Prussia, conceiving a passionate attachment to the study of astronomy, quitted the profession of medicine, and devoted himself, with the most intense ardor, to the study of this science. "His mind," it is said, "had long been imbued with the idea that simplicity and harmony should characterize the arrangements of the planetary system. In the complication and disorder which, he saw, reigned in the hypothesis of Ptolemy, he perceived insuperable objections to its being considered as a representation of nature."

In the opinions of the Egyptian sages, in those of Pythagoras, Philolaus, Aristarchus and Nicetas, he recognised his own earliest conviction that the earth was not the center of the universe. His attention was much occupied with the speculation of Martinus Capella, who placed the sun between Mars and the moon, and made Mercury and Venus revolve around him as a center; and with the system of Appollonius Pergœus, who made all the planets revolve around the sun, while the sun and moon were carried around the earth, in the center of the universe.

The examination, however, of these hypotheses gradually expelled the difficulties with which the subject was beset, and, after the labor of more than thirty years, he was permitted to see the true system of the universe. The sun he considered as immovable, in the center of the system, while the earth revolved around him, between the orbits of Venus and Mars, and produced, by its rotation about its axis all the diurnal phenomena of the celestial sphere. The other planets he considered as revolving about the sun, in orbits exterior to that of the earth.

Thus the stations and retrogradations of the planets were the necessary consequence of their own motions, combined with that of the earth about the sun. He said that, "by long observation, he discovered, that, if the motions of the planets be compared with that of the earth, and be estimated according to the times in which they perform their revolutions, not only their several appearances would follow from this hypothesis, but that it would so connect the order of the planets, their orbits, magnitudes, and distances, and even the apparent motion of the fixed stars, that it would be impossible to remove one of these bodies out of its place without disordering the rest, and even the whole of the universe also."

Soon after the death of Copernicus, arose Tycho Brahe, born at Knudstorp, in Norway, in 1546. Such was the distinction which he had attained as an astronomer, that, when dissatisfied with his residence in Denmark, he had resolved to remove, the king of Denmark, learning his intentions, detained him in the kingdom, by presenting him with the canonry of Rothschild, with an income of 2000 crowns per annum. He added to this sum a pension of 1000 crowns, gave him the island of Huen, and established for him an observatory, at an expense of about 200,000 crowns. Here Tycho continued, for twenty-one years, to enrich astronomy with his observations. His observations upon the moon were important, and upon the planets, numerous and precise, and have formed the data of the present generalizations in astronomy. He, however, rejected the system of Copernicus; considering the earth as immovable, in the center of the system; while the sun, with all the planets and comets revolving around him, performed his revolution around the earth; and, in the course of twenty-four hours, the stars also revolved about the central body. This theory was not as simple as that of Copernicus, and involved the absurdity of making the sun, planets, &c., revolve around a body comparatively insignificant.

Near the close of the 15th century, arose two men, who wrought most important changes in the science, Kepler and Galileo; the former a German, the latter an Italian.

Previous to Kepler, all investigations proceeded upon the supposition that the planets moved in circular orbits, which had been a source of much error. This supposition Kepler showed to be false. He discovered that their orbits were ellipses. The orbits of their secondaries, or moons, he also found to be the same curve. He next determined the dimensions of the orbits of the planets, and found to what their velocities in their motions through their orbits, and the times of their revolutions, were proportioned; all truths of the greatest importance to the science.

While Kepler was making these discoveries of facts, very essential for the explanation of many phenomena, Galileo was discovering wonders in the heavens never before seen by the eye of man. Having improved the telescope, and applied it to the heavens, he observed mountains and valleys upon the surface of our moon; satellites or secondaries were discovered revolving about Jupiter; and Venus, as Copernicus had predicted, was seen exhibiting all the different phases of the moon, waxing and waning as she does, through various forms. Many minute stars, not visible to the naked eye, were descried in the Milky Way; and the largest fixed stars, instead of being magnified, appeared to be small brilliant points, an incontrovertible argument in favor of their immense distance from us. All his discoveries served to confirm the Copernican theory, and to show the absurdity of the hypothesis of Ptolemy.

Although the general arrangement and motions of the planetary bodies, together with the figure of their orbits, had been thus determined, the force or power which carries them around in their orbits, was as yet unknown. The discovery of this was reserved for the illustrious Newton.* By reflecting on the nature of gravity—that power which causes bodies to descend towards the center of the earth—since it does not sensibly diminish at the greatest distance from the center of the earth to which we can attain, being as powerful on the loftiest mountains as it is in the deepest caverns—he was led to imagine that it might extend to the moon, and that it might be the power which kept her in her orbit, and caused her to revolve around the earth. He was next led to suppose that perhaps the same power carried the primary planets around the sun. By a series of calculations, he was enabled at length to establish the fact, that the same force which determines the fall of an apple to the earth, carries the moons in their orbits around the sun.

* The discovery of Newton was in some measure anticipated by Copernicus, Kepler and Hooke.

To recapitulate briefly: the system (not hypothesis, for much of it has been established by mathematical demonstration), by which we are now enabled to explain with a beautiful simplicity the different phenomena of the sun, planets, moons, and comets, is, that the sun is the central body in the system; that the planets and comets move round him in elliptical orbits, whose planes are more or less inclined to each other, with velocities bearing to each other * a certain ascertained relation, and in times related to their distances; that the moons, or secondaries, revolve in like manner, about their primaries, and at the same time accompany them in their motion around the sun: all meanwhile revolving on axes of their own; and that these revolutions in their orbits, are produced by the mysterious power of attraction. The particular mode in which this system is applied to the explanation of the different phenomena, will be exhibited as we proceed to consider, one by one, the several bodies above mentioned.

These bodies, thus arranged and thus revolving, constitute what is termed the solar system. The planets have been divided into two classes, primaries and secondaries. The latter are also termed moons, and sometimes satellites. The secondaries are those which resolve about the primaries. There have been discovered sixteen primaries; namely, Mercury, Venus, the Earth, Mars, Vesta, Juno, Ceres, Pallas, Astrea, Hebe, Iris, Flora, Melis, Jupiter, Saturn, Urauns, Neptune. Mercury is the planet nearest to the sun, then follow the others in the order in which they are named. The nine small planets between Mars and Jupiter are telescopic, and have been termed asteroids. There have been discovered nineteen secondaries, or moons. Of these, the Earth has one, Jupiter four, Saturn seven, Uranus six, and Neptune one. None of these, except our moon, are visible without telescopic aid.

We proceed to examine the objects constituting the solar system, in detail.

* The orbits or paths of the planets were discovered by tracing the course of the planet by means of the fixed stars

CHAPTER VII.

THE SUN.

The sun is a vast globe, in the center of the solar system, dispensing light and heat to all the planets, and governing all their motions.

It is the great parent of vegetable life, giving warmth to the seasons, and color to the landscape. Its rays are the cause of various vicissitudes on the surface of the earth and in the atmosphere. By their agency, all winds are produced, and the waters of the sea are made to circulate in vapor through the air, and irrigate the land, producing springs and rivers.

The sun is by far the largest of the heavenly bodies whose dimensions have been ascertained. Its diameter is something more than 883,000 miles. Consequently, it contains a volume of matter equal to *fourteen hundred thousand globes* of the size of the earth. Of a body so vast in its dimensions, the human mind, with all its efforts, can form no adequate conception. The whole distance between the earth and the moon would not suffice to embrace one-third of its diameter.

Were the sun a hollow sphere, perforated with a thousand openings to admit the twinkling of the luminous atmosphere around it—and were a globe as large as the earth placed at its center, with a satellite as large as our moon, and at the same distance from it as she is from the earth, there would be present to the eye of a spectator on the interior globe, a universe as splendid as that which now appears to the uninstructed eye—a universe as large and extensive as the whole creation was conceived to be, in the infancy of astronomy.

The next thing which fills the mind with wonder, is the *distance* at which so great a body must be placed, to occupy, apparently, so small a place in the firmament. The sun's mean distance from the earth is twelve thousand times the earth's diameter, or a little more than ninety-five millions of miles. We may derive some faint conception of such a distance, by considering that the swiftest steamboats, which ply our waters at the rate of two hundred miles a day, would not traverse it in *thirteen hundred years;* and, that a cannon ball, flying night and day, at the rate of sixteen miles a minute, would not reach it in *eleven years.*

The sun, when viewed through a telescope, presents the appearance of an enormous globe of fire, frequently in a state of violent agitation or ebullition; dark spots of irregular form, rarely visible to the naked eye, sometimes pass over his disk, from east to west, in the period of nearly fourteen days.

These spots are usually surrounded by a penumbra, and that, by a margin of light, more brilliant than that of the sun. A spot when first seen on the eastern edge of the sun, appears like a line which progressively extends in breadth, till it reaches the middle, when it begins to contract, and ultimately disappears, at the western edge. In some rare instances, the same spots re-appear on the east side, and are permanent for two or three revolutions. But, as a general thing, the spots on the sun are neither permanent nor uniform. Sometimes several small ones unite into a large one; and, again, a large one separates into numerous small ones. Some continue several days, weeks, and even months, together; while others appear and disappear, in the course of a few hours. Those spots that are formed gradually, are, for the most part, as gradually dissolved; whilst those that are suddenly formed, generally vanish as quickly.

It is the general opinion, that spots on the sun were first discovered by Galileo, in the beginning of the year 1611; though Scheiner, Harriot, and Fabricius, observed them about the same time. During a period of eighteen years from this time, the sun was never found entirely clear of spots, excepting a few days in December, 1624; at other times, they were frequently seen, twenty or thirty at a time, and in 1625, upwards of fifty were seen at once. From 1650 to 1670, scarcely any spots were to be seen; and, from 1676 to 1684, the orb of the sun presented an unspotted disk. Since the beginning of the eighteenth century scarcely a year has passed, in which spots have not been visible, and frequently in great numbers. In 1799, Dr. Herschel observed one nearly 30,000 miles in breadth.

A single second of angular measure, on the sun's disk, as seen from the earth, corresponds to 462 miles; and a circle of this diameter (containing therefore nearly 220,000 square miles) is the least space which can be distinctly discerned on the sun as a *visible area*, even by the most powerful glasses. Spots have been observed, however, whose linear diameter has been more than 44,000 miles; and, if some records are to be trusted, of even still greater extent.

Dr. Dick, in a letter to the author, says, "I have for many years examined the solar spots with considerable minuteness, and have several times seen spots which were not less than the one-twenty-fifth part of the sun's diameter, which would make them about 22,192 miles in diameter, yet they were visible neither to the naked eye, nor through an opera glass, magnifying about three times. And, therefore, if any spots have been visible to the naked eye—which we must believe, unless we refuse respectable testimony—they could not have been much less than 50,000 miles in diameter."

The apparent motion of these spots over the sun's surface, is continually varying in its direction. Sometimes they seem to move across it in *straight* lines, at others in *curve* lines. These phenomena may be familiarly illustrated in the following manner.

Fig. 1.

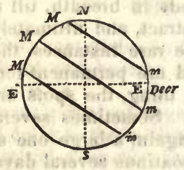
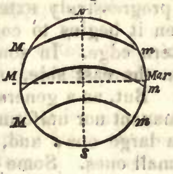


Fig. 2.



Let E E represent the ecliptic; *N S*, its north and south poles, *M* the point where the spot enters, and *m* the point where it leaves the sun's disk. At the end of November, and the beginning of December, the spot will appear to move downwards, across the sun's disk, from left to right, describing the straight lines *M m*, Fig 1; soon after this period, these lines begin gradually to be inflected towards the north, till about the end of February, or the beginning of March, when they describe the curve lines represented in Fig. 2. After the beginning of March, the curvature decreases, till the latter end of May, or the beginning of June, when they again describe straight lines tending upwards, as in Fig. 3. By and by these straight lines begin to be inflected *downwards*, till about the beginning of September, when they take the form of a curve, having its convex side towards the south pole of the sun, as in Fig. 4.

Fig. 3.

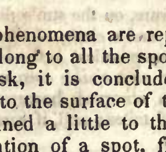
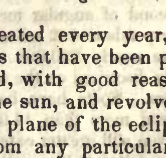


Fig. 4.



As these phenomena are repeated every year, in the same order, and belong to all the spots that have been perceived upon the sun's disk, it is concluded, with good reason, that these spots adhere to the surface of the sun, and revolve with it, upon an axis, inclined a little to the plane of the ecliptic. The apparent revolution of a spot, from any particular point of the sun's disk, to the same point again, is accomplished in 27 days, 7 hours, 26 minutes, and 24 seconds; but during that time, the spot has, in fact, gone through one revolution, together with an arc, equal to that described by the sun, in his orbit, in the same time, which reduces the time of the sun's actual rotation on his axis, to 25 days, 9 hours, and 36 minutes.

The part of the sun's disk not occupied by spots, is far from being uniformly bright. Its *ground* is finely mottled with an appearance of minute, dark dots, or *pores.* Herschel remarks that these pores, when attentively watched, are found to be in a constant state of change. This is certainly an error, if the change spoken of is one visible under the eye; for I have watched these minute pores with the greatest scrutiny, but never found while under the eye, the slightest change.

The elder Herschel conceived that the sun's body was dark or opake, and that it was surrounded by a luminous ocean or atmosphere of vast extent. Beneath this and above the sun's surface he thought there might exist a stratum of clouds, and with this constitution he proceeds to account for the phenomena of the *spots.* The black core of the spot he regards as the solid opake body of the sun, seen through an opening in the luminous atmosphere and in the floating clouds below it, while the partial shade or penumbra he attributes to the light reflected from the cloudy stratum.

I have watched the solar spots for three years with great attention, and find it quite impossible to reconcile the phenomena with any theory which supposes extreme mobility in the particles composing the exterior surface. The outline of the penumbra is seen sharp, keenly defined and cutting directly across the small mottlings or pores, as though the exterior were a crust, hard and solid, melted out from under by some internal agent. Again, the outline of the dark core of the spot eats into the penumbra sharp and sudden, sometimes in long black filaments of irregular shape, but always without any such gradual shading off as might be anticipated in case great mobility existed among the particles of matter composing the exterior coating of the sun.

The German astronomer Schwabe, of Dessau, has discovered the remarkable fact, that there is a periodical return of the solar spots. In 1828 a very large number of spots were observed. Then for five years the number decreased regularly, until in 1833 the spots counted reached a minimum; an increase now commenced, and continued yearly up to 1838, when a maximum number was reached. Then a decline commenced, and continued to 1843, when but few spots were seen. Since that year the number visible has been gradually on the increase; and during this year, 1848, I have never seen the sun without spots, and many groups have been very large.

In examining the sun, I have occasionally seen that curious phenomenon, called by the Germans "Lichtflacken" *luminous flakes.* They are brilliant points of swiftly moving light seen near the sun, and apparently as bright or even brighter than the sun itself. Some suppose them to be motes floating in the upper regions of the air; while others resist this hypothesis, without propounding any more satisfactory one.

We append the following table, exhibiting the elements of the sun as determined for the 1st of January, 1801.

Mean longitude, - -	280° 39′ 10″.2
Longitude of perigee, - -	279 30 05 .0
Greatest equation of center, - -	1 55 27 .3
Sceular diminution of center, - -	17 .2
Inclination of axis (82½°), - -	7 30 00 .0
Motion in a mean solar day, - -	59 08 .3
Motion of perigee in 365 days, - -	1 01 .9
Apparent semidiameter, - -	16 00 .0
Mean horizontal parallax, - - -	8 .6
Rotation on its axis in sidereal days, -	25 d. .01154
Time of passing one degree of mean longitude,	24 h. 20 m. 58 s. .14
Eccentricity of orbit (radius unity), - -	.0168531
Volume earth as unity, - - -	1.384,472
Mass earth as unity, - - -	354,936
Mean distance (95,000,000 miles), earth's rad. unity,	23,984
Density, or ratio of mass to volume, - -	0.2543
True diameter (883,000 miles), in diameters of earth, -	111.454

Accompanying the sun, there is an extraordinary luminous appearance, called the *zodiacal light*, which is seen at certain seasons of the year after sunset, or before sunrise, like the faint tail of a comet, extending upward from the sun, in the plane of the ecliptic. Dr. Herschel conceived this phenomenon to be a nebulous atmosphere, yet uncondensed, and surrounding the sun, whose lenticular shape arose from its rotary motion. There is great difficulty in explaining this phenomenon, on the theory of gravitation alone, for gravity will not permit material particles to remain at so great a distance from the sun as the extreme particles constituting the zodiacal light.

May not the same power which operates (as we shall hereafter see) to produce the tails of comets, on their near approach to the sun, be active in supporting, by repulsion, the particles of the zodiacal light in their great elevation above the sun's surface? We shall again refer to this subject, when we come to treat of the comets.

The direct light of the sun is greatly diminished by the atmosphere by which it is surrounded. This is manifest from the fact that the edge or disk is far less luminous than the central portion, which is directly the reverse of what ought to be exhibited in case no cause operates to absorb the light.

The light of the sun has been estimated to be more than 300,000 times greater than that of the moon. The most intense artificial light yet discovered, when seen against the sun, looks like a black spot on its surface.

MERCURY.

Mercury is the nearest planet to the sun that has yet been discovered; and, with the exception of the asteroids, is the smallest. Its diameter is only 3140 miles. Its bulk, therefore, is about 17 times less than that of the earth. It would require more than twenty millions of such globes to compose a body equal to the sun.

It revolves on its axis, from west to east, in 24 hours, 5 minutes, and 28 seconds; which makes its day about 10 minutes longer than ours. It performs its revolution about the sun in a few minutes less than 88 days, and at a mean distance of nearly thirty-seven millions of miles. The length of Mercury's year, therefore, is equal to about three of our months.

The rotation of a planet on it axis constitutes its day; its revolution about the sun constitutes its year.

Mercury is not only the most dense of all the planets, but receives from the sun seven times as much light and heat as the earth. The truth of this estimate, of course, depends upon the supposition that the intensity of solar light and heat, at the planets, varies inversely as the squares of their distances from the sun.

This law of analogy, did it exist with rigorous identity at all the planets, would be no argument against their being inhabited; because we are bound to presume that the Allwise Creator has attempered every dwelling-place in his empire to the physical constitution of the beings which he has placed in it.

From a variety of facts which have been observed in relation to the production of *caloric*, it does not appear probable that the degree of heat on the surface of the different planets depends on their respective distances from the sun. It is more probable that it depends chiefly on the distribution of the *substance of caloric* on the surfaces, and throughout the atmospheres of these bodies, in different quantities, according to the different situations which they occupy in the solar system; and that these different quantities of caloric are put into action by the influence of the solar rays, so as to produce that degree of *sensible* heat requisite to the wants, and to the greatest benefit of each of the planets. On this hypothesis, which is corroborated by a great variety of facts and experiments, there may be no more sensible heat experienced on the planet Mercury than on the surface of Herschel, which is fifty times further removed from the sun.

Owing to the dazzling brightness of Mercury, the swiftness of its motion, and its nearness to the sun, astronomers have made but comparatively few discoveries respecting it. When viewed through a telescope of considerable magnifying power, it exhibits, at different periods, all the various phases of the moon; except that it never appears quite full, because its enlightened hemisphere is never turned directly toward the earth, only when it is *behind* the sun, or so near to it as to be hidden by the splendor of its beams. Its enlightened hemisphere being thus always turned toward the sun, and the opposite one being always dark, prove that it is an opake body, similar to the earth, shining only in the light which it receives from the sun.

The rotation of Mercury on its axis was determined, from the daily position of its horns, by M. Schroeter, who not only discovered spots upon its surface, but several mountains in its southern hemisphere, one of which was $10\frac{3}{4}$ miles high—nearly three times as high as Chimborazo, in South America.

It is worthy of observation, that the highest mountains which have been discovered in Mercury, Venus, the moon, and, perhaps, we may add, the earth, are all situated in their southern hemispheres.

During a few days in March and April, August and September, Mercury may be seen for several minutes, in the morning or evening twilight, when its greatest elongations happen in those months; in all other parts of its orbit, it is too near the sun to be seen by the naked eye. The greatest distance that it ever departs from the sun, on either side, varies from 16° 12′ to 28° 48′, *alternately*.

The revolution of Mercury about the sun, like that of all the planets, is performed from west to east, in an orbit which is nearly circular. Its *apparent* motion, as seen from the earth, is, alternately, from west to east, and from east to west, nearly in straight lines; sometimes, directly across the face of the sun, but at all other times either a little above or a little below it.

Being commonly immersed in the sun's rays in the evening, and thus continuing invisible until it emerges from them in the morning, it appeared to the ancients like two distinct stars. A long series of observations was requisite before they recognized the identity of the star which was seen to recede from the sun in the morning with that which approached it in the evening. But as the one was never seen until the other disappeared, both were at last found to be the *same* planet, which thus oscillated on each side of the sun.

Mercury's oscillation from west to east, or from east to west, is really accomplished in just half the time of its revolution, which is about 44 days; but as the earth, in the meantime, follows the sun in the same direction, the apparent elongations will be prolonged to between 55 and 65 days.

The passage of Mercury over the sun's disk is denominated a *transit*. This would happen in every revolution, if the orbit lay in the same plane with the orbit of the earth. But it does not;

it cuts the earth's orbit in two opposite points, as the ecliptic does the equator, but at an angle three times less.

These points of intersection are called the *nodes* of the orbit. Mercury's ascending node is in the 16th degree of Taurus; its descending node in the 16th degree of Scorpio. As the earth passes these nodes in November and May, the transits of Mercury must happen, for many ages to come, in one of these months.

The following is a list of all the transits of Mercury, from the time the first was observed, by Gassendi, November 6, 1631, to the end of the present century.

1631 Nov. 6.	1707 May 5.	1776 Nov. 2.	1835 Nov. 7.
1644 Nov. 6.	1710 Nov. 6.	1782 Nov. 12.	1845 May 8.
1651 Nov. 2.	1723 Nov. 9.	1786 May 3.	1848 Nov. 9.
1661 May 3.	1736 Nov. 10.	1789 Nov. 5.	1861 Nov. 11.
1664 Nov. 4.	1740 Nov. 2.	1799 May 7.	1868 Nov. 4.
1674 May 6.	1743 Nov. 4.	1802 Nov. 8.	1878 May 6.
1677 Nov. 7.	1753 May 5.	1815 Nov. 11.	1881 Nov. 7.
1690 Nov. 9.	1756 Nov. 6	1822 Nov. 4.	1891 May 9.
1697 Nov. 2.	1769 Nov. 9.	1832 May 5.	1894 Nov. 10.

By comparing the mean motion of any of the planets with the mean motion of the earth, we may, in like manner, determine the periods in which these bodies will return to the same points of their orbit, and the same positions with respect to the sun. The knowledge of these periods will enable us to determine the hour when the planets rise, set, and pass the meridian, and, in general, all the phenomena dependent upon the relative position of the earth, the planet, and the sun; for at the end of one of these periods they commence again, and all recur in the same order. We have only to find a number of sidereal years, in which the planet completes exactly, or very nearly, a certain number of revolutions; that is, to find such a number of planetary revolutions as, when taken together, shall be exactly equal to one, or any number of revolutions of the earth. In the case of Mercury, this ratio will be as 87.969 is to 365.256. Whence we find, that—

7 periodical revolutions of the earth are equal to 29 of Mercury:
13 periodical revolutions of the earth are equal to 54 of Mercury:
33 periodical revolutions of the earth are equal to 137 of Mercury:
46 periodical revolutions of the earth are equal to 191 of Mercury.

Therefore, transits of Mercury, at the same node, may happen at intervals of 7, 13, 33, 46, &c., years. Transits of Venus, as well as eclipses of the sun and moon, are calculated upon the same principle.

The *sidereal* revolution of a planet respects its *absolute* motion, and is measured by the time the planet takes to revolve from any fixed star to the same star again.

The *synodical* revolution of a planet respects its *relative* motion, and is measured by the time that a planet occupies in coming back to the same position, with respect to the earth and the sun.

The sidereal revolution of Mercury is 87 d. 23 h. 15 m. 44 s. Its *synodical* revolution is found by dividing the whole circumference of 360° by its *relative* motion in respect to the earth. Thus, the mean daily motion of Mercury is 14′ 32″.555; that of the earth is 3548″.318; and their difference is 11184″.237, being Mercury's relative motion, or what it gains on the earth every day. Now, by simple proportion, 11184″.237 is to 1 day as 360° is to 115 d. 21 h. 3 m. 25 s., the period of a synodical revolution of Mercury.

The *absolute* motion of Mercury in its orbit, is 109,757 miles an hour; that of the earth, is 68,288 miles: the difference, 41,469 miles, is the mean *relative* motion of Mercury, with respect to the earth. The transit of Mercury across the disk of the sun, which occurred on the 8th of May, 1845, was observed at the Cincinnati observatory. By the new tables of Leverrier, its place was predicted, so that the various contacts with the sun took place to within sixteen seconds of the computed time. The planet was seen very distinctly as a round black spot on the bright surface of the sun. The density of the planet, and its absolute diameter, enable us to determine the force of gravitation at its surfaces. A heavy body would fall through 17.7 feet per second on Mercury, and a pound of matter removed from the earth to the planet would weigh 1,106 pounds.

These are the elements of Mercury for mean noon, Greenwich, 1st Jan. 1801.

Mean sidereal revolution,	87 d. 23 h. 15 m. 43 s. .9
Mean longitude,	166° 00′ 48″.6
Longitude of perihelion,	74 21 46 .9
Annual motion of the line of apsides,	5 .8
Ditto, referred to the ecliptic,	55 .9
Longitude of the ascending node,	45° 37′ 30 .9
Motion of ditto, west per annum,	7 .8
Ditto, east referred to the ecliptic,	42 .3
Mean orbital motion in a solar day,	4° 05′ 32 .6
Inclination of orbit,	7 00 10 .0
Eccentricity of orbit, half major, axis unity	0,210,551,494
Decrease of ditto, in a century,	0,000,003,866
Greatest equation of center,	23° 39′ 51″.0
Increase of ditto, in a century,	1 .6
Axical rotation,	24 h. 05 m. 28 s. .3
Mean apparent diameter,	6″.9
True diameter (3140 miles) earth as unity,	0 .398
Minimum elongation,	16° 12′ 00″
Maximum ditto,	28 48 00
Volume earth as unity,	0,063
Mass sun as unity,	0,000,000,4936
Mean distance (36, 000,000 miles) earths as unity,	0,3870981

VENUS.

THERE are but few persons who have not observed a beautiful star in the west, a little after sunset, called the *evening star*. This star is Venus. It is the second planet from the sun. It is the brightest star in the firmament, and on this account easily distinguished from the other planets.

If we observe this planet for several days, we shall find that it does not remain constantly at the same distance from the sun, but that it appears to approach, or recede from him, at the rate of about three-fifths of a degree every day; and that it is sometimes on the east side of him, and sometimes on the west, thus continually oscillating backward and forward between certain limits.

As Venus never departs quite 48° from the sun, it is never seen at midnight, nor in opposition to that luminary; being visible only about three hours after sunset, and as long before sunrise, according as its right ascension is greater or less than that of the sun. At first we behold it only a few minutes after sunset; the next evening we hardly discover any sensible change in its position; but after a few days, we perceive that it has fallen considerably behind the sun, and that it continues to depart farther and farther from him, setting later and later every evening, until the distance between it and the sun, is equal to a little more than half the space from the horizon to the zenith, or about 46°.

It now begins to return toward the sun, making the same daily progress that it did in separating from him, and to set earlier and earlier every succeeding evening, until it finally sets with the sun, and is lost in the splendor of his light.

A few days after the phenomena we have now described, we perceive, in the morning, near the eastern horizon, a bright star which was not visible before. This also is Venus, which is now called the *morning star*. It departs farther and farther from the sun, rising a little earlier every day, until it is seen about 46° west of him, where it appears stationary for a few days; then it resumes its course towards the sun, appearing later and later every morning, until it rises with the sun, and we cease to behold it. In a few days, the evening star again appears in the west, very near the setting sun, and the same phenomena are again exhibited. Such are the visible appearances of Venus.

Venus revolves about the sun from west to east in $224\frac{2}{3}$ days, at the distance of about 68,000,000 of miles, moving in her orbit at the rate of eighty thousand miles an hour. She turns around on her axis once in 23 hours, 21 minutes, and 7 seconds. Thus her day is about 25 minutes shorter than ours, while her year is equal to 7½ of our months, or 32 weeks.

The mean distance of the earth from the sun, is estimated at 95,000,000 of miles, and that of Venus being 68,000,000, the diameter of the sun, as seen from Venus, will be to his diameter as seen from the earth, as 95 to 68, and the surface of his disk as the square of 95 to the square of 68, that is, as 9025 to 4626, or as 2 to 1 nearly. The intensity of light and heat being inversely as the squares of their distances from the sun, Venus receives twice as much light and heat as the earth.

Her orbit is within the orbit of the earth; for if it were not, she would be seen as often in opposition to the sun, as in conjunction with him; but she was never seen rising in the east, while the sun was setting in the west. Nor was she ever seen in quadrature, or on the meridian, when the sun was either rising or setting. Mercury being about 23° from the sun, and Venus 46°, the orbit of Venus must be *outside* of the orbit of Mercury.

The *true* diameter of Venus is 7700 miles; but her *apparent* diameter and brightness are constantly varying, according to her distance from the earth. When Venus and the earth are on the same side of the sun, her distance from the earth is only 26,000,000 of miles; when they are on opposite sides of the sun, her distance is 164,000,000 of miles. Were the whole of her enlightened hemisphere turned towards us, when she is nearest, she would exhibit a light and brilliancy twenty-five times greater than she generally does, and appear like a small brilliant moon; but, at that time, her dark hemisphere is turned towards the earth.

When Venus approaches nearest to the earth, her *apparent* or observed diameter, is 61″.2; when most remote it is only 9″.6: now $61''.2 \div 9''.6 = 6\frac{3}{8}$, hence when nearest the earth, her apparent diameter is $6\frac{3}{8}$ times greater than when most distant, and the surface of her disk $(6\frac{3}{8})^2$ or nearly 41 times greater. In this work, the apparent size of the heavenly bodies is estimated from the apparent surface of their disks, which is always proportional to the squares of their apparent diameters.

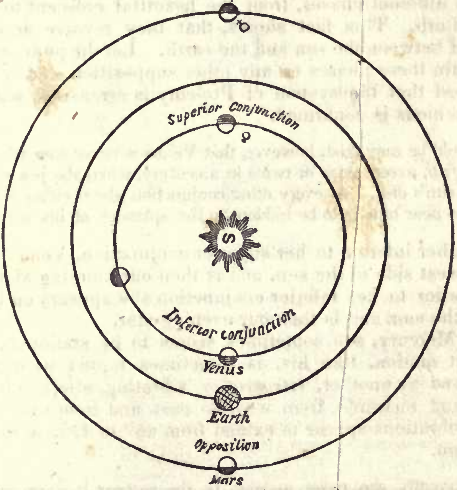
When Venus's right ascension is less than that of the sun, she rises before him; when greater, she appears after his setting. She continues alternately morning and evening star, for a period of 292 days, each time.

To those who are but little acquainted with astronomy, it will seem strange, at first, that Venus should apparently continue longer on the east or west side of the sun, than the whole time of her periodical revolution around him. But it may be easily understood, when it is considered, that while Venus moves around the sun, at the rate of about 1° 36′ of angular motion per day, the earth follows at the rate of 59′; so that Venus actually gains on the earth, only 37′ in a day.

Now it is evident that both planets will appear to keep on the same side of the sun, until Venus has gained half her orbit, or 180° in advance of the earth; and this at a mean rate, will require 292 days, since, $292\times 37'=10804'$, or 180° nearly.

Mercury and Venus are called *Inferior** planets, because their orbits are within the earth's orbit, or between it and the sun. The other planets are denominated *Superior*, because their orbits are without or beyond the orbit of the earth. As the orbits of Mercury and Venus lie *within* the earth's orbit, it is plain, that once in every synodical revolution, each of these planets will be in conjunction on the same side of the sun. In the former case, the planet is said to be in its *inferior conjunction*, and in the latter case, in its *superior conjunction*; as in the following figure.

CONJUNCTION AND OPPOSITION OF THE PLANETS.



* In almost all works on astronomy, Mercury and Venus are denominated *inferior* planets, and the others *superior*. But as these terms are employed, not to express the relative *size* of the planets, but to indicate their *situation* with respect to the earth, it would be better to adopt the terms *interior* and *exterior*.

The period of Venus's synodical revolution, is found in the same manner as that of Mercury; namely, by dividing the whole circumference of her orbit by her mean *relative* motion in a day. Thus, Venus's *absolute* mean daily motion, is 1° 36′ 7″.8, the earth's is 59′ 8″.3, and their difference 36′ 59″.5. Divide 360° by 36′ 59″.5, and it gives 583.920; or nearly 584 days, for Venus's synodical revolution, or the period in which she is twice in conjunction with the earth.

Venus passes from her inferior to her superior conjunction in about 292 days. At her inferior conjunction, she is 26,000,000 of miles from the earth; at her superior conjunction, 164,000,000 of miles.

It might be expected that her brilliancy would be proportionally increased, in the one case, and diminished, in the other; and so it would be, were it not that her enlightened hemisphere is turned more and more from us, as she approaches the earth, and comes more and more into view as she recedes from it. It is to this cause alone that we must attribute the uniformity of her splendor as it usually appears to the naked eye.

Mercury and Venus present to us, successively, the various shapes and appearances of the moon; waxing and waning through different phases, from the beautiful crescent to the full rounded orb. This fact shows, that they revolve around the sun, and between the sun and the earth. Let the pupil endeavor to explain these phases on any other supposition, and he will be convinced that the system of Ptolemy is erroneous, while that of Copernicus is confirmed.

It should be remarked, however, that Venus is never *seen* when she is entirely *full*, except once or twice in a century, when she passes directly over the sun's disk. At every other conjunction, she is either *behind* the sun, or so near him as to be hidden by the splendor of his light.

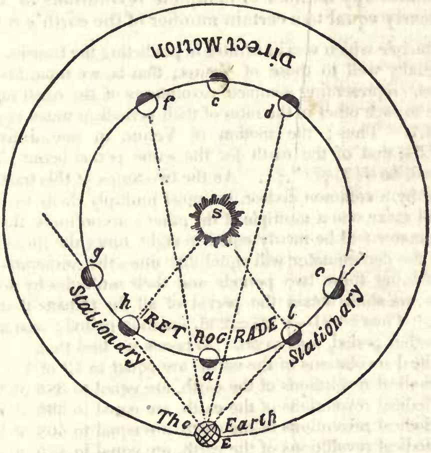
From her inferior to her superior conjunction, Venus appears on the west side of the sun, and is then our morning star; from her superior to her inferior conjunction she appears on the east side of the sun, and is then our evening star.

Like Mercury, she sometimes seems to be stationary. Her apparent motion, like his, is sometimes rapid; at one time, *direct*, and at another, *retrograde;* vibrating alternately backwards and forwards, from west to east, and from east to west. These vibrations appear to extend from 45° to 47°, on each side of the sun.

Consequently she never appears in the eastern horizon, more than three hours before sunrise, nor continues longer in the western horizon, after sunset. Any star or planet, therefore, however brilliant it may appear, which is seen earlier or later than this, cannot be Venus.

In passing from her western to her eastern elongation, her motion is from west to east, *in the order of the signs;* it is thence called *direct* motion. In passing from her eastern to her western elongation, her motion with respect to the earth, is from east to west, *contrary* to the order of the signs; it is thence denominated *retrograde motion.* Her motion appears quickest about the time of her conjunctions, and she seems stationary, at her elongations. She is brightest about thirty-six days before and after her inferior conjunction, when her light is so great as to project a visible shadow in the night, and sometimes she is visible even at noon-day.

DIRECT AND RETROGRADE MOTION.



In the foregoing figure, the outer circle represents the earth's orbit, and the inner circle, that of Venus, while she moves around the sun, in the order of the letters *a, b, c, d,* &c. When Venus is at *a*, she is in her inferior conjunction, between the earth and sun; and is in a situation similar to that of the moon at her change, being then invisible, because her dark hemisphere is towards the earth. At *c*, she appears half enlightened to the earth, like the moon in her first quarter; at *d*, she appears almost full, her enlightened side being then almost directly towards the earth; at *e*, she is in her superior conjunction, and would appear quite full, were she not directly *behind* the sun, or so near him as to be hidden by the splendor of his light; at *f*, she appears to be on the decrease; and at *g*, only half enlightened, like the moon in her last quarter; at *a*, she disappears again between the earth and the sun. In moving from *g* to *c*, she seems to go *backwards* in the heavens, because she moves contrary to the order of the signs. In turning the arc of the circle from retrograde to direct motion, or from direct to retrograde, she appears nearly stationary for a few days; because, in the former case, she is going almost directly *from* the earth, and in the latter coming *towards* it. As she describes a much larger portion of her orbit in going from *c* to *g*, than from *g* to *c*, she appears much longer direct than retrograde. At a mean rate, her retrogradations are accomplished in forty-two days.

If the orbit of Venus lay exactly in the plane of the earth's orbit, she would pass centrally across the sun's disk, like a dark round spot, at every inferior conjunction; but as one half of her orbit lies about $3\frac{1}{3}^{\circ}$ above the ecliptic, and the other half as far below it, she will always pass the sun a very little above or below it, except when her inferior conjunction happens in, or near, one of her nodes; in which case she will make a transit.

This phenomenon, therefore, is of very rare occurrence: it can happen only twice in a century; because it is only twice in that time that any number of complete revolutions of Venus, are just or nearly equal to a certain number of the earth's revolutions.

The principle which was illustrated in predicting the transits of Mercury applies equally well to those of Venus; that is, we must find such sets of numbers, (representing complete revolutions of the earth and Venus), as shall be to each other in the ratio of their periodical times, or as 365.256 is to 224.7. Thus; the motion of Venus, in one Julian year, is 2106591″.52, that of the earth for the same period being 129627″·45, the ratio will be $\frac{2106591''.52}{129627''.45}$. As the two terms of this fraction cannot be reduced by a common divisor, we must multiply them by such numbers as will make one a multiple of the other; accordingly, thirteen times the denominator will be nearly equal to eight times the numerator; and 475 times the denominator will equal 291 times the numerator.

By combining these two periods and their multiples by addition and subtraction, we shall obtain the period of all the transits that have ever happened. Thus: $291-8\times7=235$, another period; and $291-6\times8=243$, another period, and so on. Whence we find that,

8 periodical revolutions of the earth, are equal to 13 of Venus.
235 periodical revolutions of the earth, are equal to 382 of Venus.
243 periodical revolutions of the earth, are equal to 395 of Venus.
251 periodical revolutions of the earth, are equal to 408 of Venus.
291 periodical revolutions of the earth, are equal to 475 of Venus.

Hence a transit of Venus may happen at the same node, after an interval of eight years; but if it do not happen then, it cannot take place again, at the same node, in less than 235 years. The orbit of Venus crosses the ecliptic near the middle of Gemini and Sagittarius; and these points mark the position of her nodes. At present her ascending node is in the 14th degree of Gemini, and her descending node, in the same degree of Sagittarius.

The earth passes her ascending node in the beginning of December, and her descending node, in the beginning of June. Hence, the transits of Venus, for ages to come, will happen in December and June. The first transit ever known to have been seen by any human being, took place at the ascending node, December 4th, 1639.* If to this date, we add 235 years, we shall have the time of the next transit at the same node, which will accordingly happen in 1874. There will be another at the same node in 1882, eight years afterwards. It is not more certain that this phenomenon will recur, than that the event itself will engross the attention of all the astronomers then living upon the earth. It will be anticipated, and provided for, and observed, in every inhabited quarter of the globe, with an intensity of solicitude which no natural phenomenon since the creation, has ever excited.

The reason why a transit of Venus should excite so great an interest, is, because it may be expected to solve an important problem in astronomy, which has never yet been satisfactorily done:—a problem whose solution will make known to us the magnitudes and masses of all the planets, the true dimensions of their orbits, their rates of motion around the sun, and their respective distances from the sun, and from each other. It may be expected, in short, to furnish a universal standard of astronomical measure. Another consideration will render the observation of this transit peculiarly favorable; and that is, astronomers will be supplied with better instruments, and more accurate means of observation, than on any former occasion.

* This phenomenon was first witnessed by Horrox, a young gentleman about twenty-one years of age, living in an obscure village fifteen miles north of Liverpool. The tables of Kepler, constructed upon the observations of Tycho Brahe, indicated a transit of Venus in 1631, but none was observed. Horrox, without much assistance from books and instruments, set himself to inquire into the error of the tables, and found that such a phenomenon might be expected to happen in 1639. He repeated his calculations during this interval, with all the carefulness and enthusiasm of a scholar ambitious of being the first to predict and observe a celestial phenomenon, which, from the creation of the world, had never been witnessed. Confident of the result, he communicated his expected triumph to a confidential friend residing in Manchester, and desired him to watch for the event, and to take observations. So anxious was Horrox not to fail of witnessing it himself, that he commenced his observations the day before it was expected, and resumed them at the rising of the sun on the morrow. But the *very hour* when his calculations led him to expect the visible appearance of Venus upon the sun's disk. *was also the appointed hour for the public worship of* God *on the Sabbath.* The delay of a few minutes might deprive him forever of an opportunity of observing the transit. If its very commencement were not noticed, clouds might intervene, and conceal it until the sun should set: and nearly a century and a half would elapse before another opportunity would occur. He had been waiting for the event with the most ardent anticipation for eight years, and the result promised much benefit to the science. *Notwithstanding all this, Horrox twice suspended his observations, and twice repaired to the house of God,* the Great Author of the bright worlds he delighted to contemplate. When his duty was thus performed, and he had returned to his chamber the second time, his love of science was gratified with full success; and he saw what no mortal eye had observed before!

If any thing can add interest to this incident, it is the modesty with which the young astronomer apologizes to the world, for *suspending* his observations at all.

"I observed it," says he, "from sunrise till nine o'clock, again a little before ten, and lastly at noon, and from one to two o'clock; the rest of the day being devoted to higher duties, which might not be neglected for these pastimes."

So important, says Sir John Herschel, have these observations appeared to astronomers, that at the last transit of Venus, in 1769, expeditions were fitted out, on the most efficient scale, by the British, French, Russian, and other governments, to the remotest corners of the globe, for the express purpose of making them. The celebrated expedition of Captain Cook to Otaheite, was one of them. The general result of all the observations made on this most memorable occasion, gives 8″.5776 for the sun's horizontal parallax.

The phenomena of the seasons, of each of the planets, like those of the earth, depend upon the inclination of the axis of the planet, to the plane of its orbit. The inclination of the axis of Venus to the plane of her orbit, though not precisely known, is commonly estimated at 75°; which is more than three times as great as the inclination of the earth's axis to the plane of the ecliptic. The north pole of Venus's axis inclines towards the 20th degree of Aquarius; the earth's towards the beginning of Cancer; consequently, the northern parts of Venus have summer in the signs where those of the earth have winter, and vice versa.

The declination of the sun on each side of her equator, must be equal to the inclination of her axis; and if this extends to 75°, her tropics are only 15° from her poles, and her polar circles 15° from her equator. It follows, also, that the sun must change his declination more in one day at Venus, than in five days on the earth; and consequently, that he never shines vertically on the same places for two days in succession. This may perhaps be providentially ordered, to prevent too great effect of the sun's heat, which, on the supposition that it is in inverse proportion to the square of the distance, is twice as great on this planet as it is on the earth.

At each pole, the sun continues half a year * without setting in summer, and as long without rising in winter; consequently, the polar inhabitants of Venus, like those of the earth, have only one day and one night in the year; with this difference, that the polar days and nights of Venus are not quite two-thirds as long as ours.

Between her polar circles, which are but 15° from her equator, there are two winters, two summers, two springs, and two autumns, every year. But because the sun stays for some time near the tropics, and passes so quickly over the equator, the winters in that zone will be almost twice as long as the summers.

When viewed through a good telescope, Venus exhibits not only all the moon-like phases of Mercury, but also a variety of inequalities on her surface; dark spots, and brilliant shades, hills, and valleys, and elevated mountains. But on account of

* That is, *half of Venus's year*, or sixteen weeks.

the great density of her atmosphere, these inequalities are perceived with more difficulty than those upon the other planets.

The mountains of Venus, like those of Mercury and the moon, are highest in the southern hemisphere. According to M. Schroeter, a celebrated German astronomer, who spent more than ten years in observation upon this planet, some of her mountains rise to the enormous hight of from ten to twenty-two miles.* The observations of Dr. Herschel do not indicate so great an altitude; and he thinks, that in general they are considerably overrated. He estimates the diameter of Venus at 8,649 miles; making her bulk more than one-sixth larger than that of the earth. Several eminent astronomers affirm, that they have repeatedly seen Venus attended by a satellite, and they have given circumstantial details of its size and appearance, its periodical revolution and its distance from her. It is said to resemble our moon in its phases, its distance, and its magnitude. Other astronomers deny the existence of such a body, because it was not seen with Venus on the sun's disk, at the transits of 1761, and 1769.

The general elements of this planet for the epoch 1st January, 1801, are as follows:

Mean sidereal revolution,	224 d. 16 h. 49 m. 08s.00
Mean synodical revolution in solar days,	583.92
Mean longitude,	11° 33′ 03″.00
Mean daily motion in orbit,	1 36 07 .80
Longitude of perihelion,	128 43 53 .10
W. motion of apsides per annum,	02 .70
E. " " referred to the ecliptic,	47 .40
Inclination of orbit,	3 23 28 .5
Annual increase of do.,	00 .5
Longitude of ascending node,	74 54 12 .9
W. motion of do. per annum,	17 .6
E. " " referred to the ecliptic,	32 .5
Eccentricity of orbit, half maj. axis as unity,	0.00686074
Decrease of do. in a century,	0.000062711
Greatest equation of center,	47′ 15″.00
Annual decrease of do.,	00 .25
Rotation on axis,	23 h. 21 m. 07s.2
Mean apparent diameter,	16″.9
Diameter at superior conjunction,	09 .6
Diameter at inferior conjunction,	1′ 01″.2
True diameter (7700 miles) earth's as unity,	0.975
Volume earth's as unity,	0.927
Mass sun's as unity,	0.0000024638
Mean distance from the sun, (68,000,000 miles), earth's as unity,	0.7233316

* 1st, 22.05 miles; 2d, 18.97 miles; 3d, 11.44 miles; 4th. 10.84 miles.

THE EARTH.

The earth is the place from which all our observations of the heavenly bodies must necessarily be made. The apparent motions of these bodies being very considerably affected by her figure, motions, and dimensions, these hold an important place in astronomical science. It will, therefore, be proper to consider, first, some of the methods by which they have been determined.

If, standing on the sea-shore, in a clear day, we view a ship leaving the coast, *in any direction*, the hull, or body of the vessel, first disappears; afterward the rigging, and, lastly, the top of the mast vanishes from our sight. Those on board the ship observe that the coast first sinks below the horizon, then the buildings, and, lastly, the tallest spires of the city, which they are leaving. Now these phenomena are evidently caused by the convexity of the water which is between the eye and the object; for, were the surface of the sea merely an extended plain, the largest objects would be visible the longest, and the smallest disappear first.

Again, navigators have sailed quite around the earth, and thus proved its convexity.

Ferdinand Magellan, a Portuguese, was the first who carried this enterprise into execution. He embarked from Seville, in Spain, and directed his course toward the west. After a long voyage, he descried the continent of America. Not finding an opening to enable him to continue his course in a westerly direction, he sailed along the coast toward the south, until, coming to its southern extremity, he sailed around it, and found himself in the great Southern Ocean. He then resumed his course toward the west. After some time, he arrived at the Molucca Islands, in the *Eastern Hemisphere;* and, sailing continually toward the west, he made Europe from the east,—arriving at the place from which he set out.*

The next who circumnavigated the earth, was Sir Francis Drake, who sailed from Plymouth, December 13, 1577, with five small vessels, and arrived at the same place, September 26, 1580. Since that time, the circumnavigation of the earth has been performed by Cavendish, Cordes, Noort, Sharten, Heremites, Dampier, Woodes, Rogers, Schovten, Roggewin, Lord Anson, Byron, Carteret, Wallis, Bougainville, Cook, King, Clerk, Vancouver, and many others.

* Magellan sailed from Seville, in Spain, August 10, 1519, in a ship called the Victory, accompanied by four other vessels. In April, 1521, he was killed in a skirmish with the natives, at the island of *Sebu*, or *Zebu*, sometimes called Matan, one of the Philippines. One of his vessels, however, arrived at St. Lucar, near Seville, September 7, 1522.

These navigators, by sailing in a westerly direction, allowance being made for promontories, &c., arrived at the country they sailed from. Hence, the earth must be either cylindrical or globular. It cannot be cylindrical, because, if so, the meridian distances would all be equal to each other, which is contrary to observation. The figure of the earth is, therefore, spherical.

The convexity of the earth, north and south, is proved by the altitude of the pole, and of the circumpolar stars, which is found uniformly to increase as we approach them, while the inclination to the horizon, of the circles described by all the stars, gradually diminishes. While proceeding in a southerly direction, the reverse of this takes place. The altitude of the pole, and of the circumpolar stars, continually decreases; and all the stars describe circles whose inclination to the horizon increases with the distance. Whence we derive this general truth: *The altitude of one pole, and the depression of the other, at any place on the earth's surface, is equal to the latitude of that place.*

Another proof of the convexity of the earth's surface is, that the higher the eye is raised, the further is the view extended. An observer may see the setting sun from the top of a house, or any considerable eminence, after he has ceased to be visible to those below.

The curvature of the earth for one mile is eight inches; and this curvature increases with the square of the distance. From this general law, it will be easy to calculate the distance at which any object, whose hight is given, may be seen, or to determine the hight of an object, when the distance is known.

1. To find the hight of an object when the distance is given.

RULE. *Find the square of the distance in miles, and take two-thirds of that number for the hight in feet.*

Ex. 1. How high must the eye of an observer be raised, to see the surface of the ocean, at the distance of 3 miles? *Ans.* The square of 3 feet is 9 feet, and $\frac{2}{3}$ of 9 feet is 6 feet.

Ex. 2. Suppose a person can just see the top of a spire, over an extended plain of 10 miles, how high is the steeple? *Ans.* The square of 10 is 100, and $\frac{2}{3}$ of 100 is $66\frac{2}{3}$ feet.

2. To find the distance when the hight is given.

RULE. *Increase the hight in feet one-half, and extract the square root, for the distance, in miles.*

Ex. 1. How far can a person see the surface of a plain, whose eye is elevated 6 feet above it? *Ans.* 6, increased by its half, is 9, and the square root of 9 is 3: the distance is, then, 3 miles.

Ex. 2. To what distance can a person see a light-house whose hight is 96 feet from the level of the ocean? *Ans.* 96, increased by its half, is 144, and the square root of 144 is 12: the distance is, therefore, 12 miles.

3. To find the curvature of the earth when it exceeds a mile.

RULE. *Multiply the square of the distance by* .000126.

Although it appears, from the preceding facts, that the earth is spherical, yet it is not a perfect sphere. If it were, the length of the degrees of latitude, from the equator to the poles, would be uniformly the same; but it has been found, by the most careful measurement, that, as we go from the equator toward the poles, the length *increases with the latitude.*

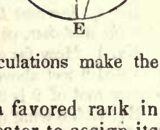
These measurements have been made by the most eminent mathematicians of different countries, and in various places, from the equator to the arctic circle. They have found that a degree of latitude at the arctic circle was *nine sixteenths* of a mile longer than a degree at the equator, and that the ratio of increase, for the intermediate degrees, was nearly as the squares of the sines of the latitude. Thus the theory of Sir Isaac Newton was confirmed, that the body of the earth was more rounded and convex between the tropics, but considerably flattened toward the poles.

Places of Observation.	*Latitude.*	*Length of a degree in English miles.*	*Observers.*
Peru,	Equator	68.732	Bouguer,
Pennsylvania,	39° 12′ 00″ N.	68.896	Mason and Dixon,
Italy,	43 01 00	68.998	Boscovich and Lemaire
France,	46 00 00	69.054	Delambre and Mechain
England,	51 29 54½	69.146	Mudge,
Sweden.	66 20 10	69.292	Swamberg.

These measurements prove the earth to be an *oblate spheroid*, whose longest or equatorial diameter is 7924 miles, and the polar diameter, 7898 miles. The mean diameter is, therefore, about 7911, and their difference 26 miles. The French Academy have determined that the mean diameter of the earth, from the 45th degree of north latitude, to the opposite degree of south latitude, is, *accurately*, 7912 miles.

If the earth were an exact sphere, its diameter might be determined by its curvature, from a single measurement. Thus, in the adjoining figure, we have A B equal to 1 mile, and B D equal to 8 inches, to find A E, or B E, which does not sensibly differ from A E, since B D is only 8 inches. Now, it is a proposition of Euclid, (B. 3, prop. 36,) that, when, from a point without a circle, two lines be drawn, one cutting and the other touching it, the touching line (B A) is a mean proportional between the cutting line (B E) and that part of it (B D) without the circle.

Fig. 10



B D : B A : : B A : B E or A E very nearly.

That is, 1 mile being equal to 63360 inches,

8 : 63360 : : 63360 : 501811120 inches, or 7920 miles.

This is very nearly what the most elaborate calculations make the earth's equatorial diameter.

The earth, considered as a planet, occupies a favored rank in the solar system. It pleased the all wise Creator to assign its position among the heavenly bodies where nearly all the sister planets are visible to the naked eye. It is situated next to Venus, and is the third planet from the sun.

To the scholar who, for the first time, takes up a book on astronomy, it will no doubt seem strange to find the earth classed with the heavenly bodies. For what can appear more unlike than the earth, with her vast and seemingly immeasurable extent, and the stars, which appear but as points? The earth is dark and opake; the celestial bodies are brilliant. We perceive in it no motion, while in them we observe a continual change of place, as we view them at different hours of the day or night, or at different seasons of the year.

It moves round the sun, from west to east, in 365 days, 5 hours, 48 minutes, and 48 seconds; and turns, the same way, on its axis, in 23 hours, 56 minutes, and 4 seconds. The former is called its *annual* motion, and causes the vicissitudes of the seasons. The latter is called its *diurnal* motion, and produces the succession of day and night.

The earth's mean distance from the sun is about 95,000,000 of miles; it, consequently, moves in its orbit at the mean rate of 68,000 miles an hour. Its equatorial diameter being 7924 miles, it turns on its axis at the rate of 1040 miles an hour.

Thus, the earth, on which we stand, and which has served for ages as the unshaken foundation of the firmest structures, is every moment turning swiftly on its center, and, at the same time, moving onward with great rapidity through the empty space.

This compound motion is to be understood of the *whole earth*, with all that it holds within its substance, or sustains upon its surface—of the solid mass beneath, of the ocean which flows around it, of the air that rests upon it, and of the clouds which float above it in the air.

That the earth, in common with all the planets, revolves around the sun as a center, is a fact which rests upon the clearest demonstrations of philosophy. That it revolves, like them, upon its own axis, is a truth which every rising and setting sun illustrates, and which very many phenomena concur to establish.

Either the earth moves around its axis every day, or *the whole universe* moves around it in the same time. There is no third opinion that can be formed on this point. Either the earth must revolve on its axis every 24 hours, to produce the alternate succession of day and night, or the sun, moon, planets, comets, fixed stars, and the whole frame of the universe itself, must move around the earth, in the same time. To suppose the latter case to be the fact, would be to cast a reflection on the wisdom of the Supreme Architect, whose laws are universal harmony. As well might the beetle, that in a moment turns on its ball, imagine the heavens and the earth had made a revolution in the same instant. It is evident, that in proportion to the distance of the celestial bodies from the earth, must, on this supposition, be the rapidity of their movements. The sun, then, would move at the rate of more than four hundred thousand miles in a minute; the nearest stars, at the inconceivable velocity of fourteen hundred millions of miles in a *second;* and the most distant luminaries, with a degree of swiftness which no numbers could express,—and all this to save the little globe we tread upon from turning safely on its axis once in 24 hours.

The idea of the heavens revolving about the earth, is encumbered with innumerable other difficulties. We will mention only one more. It is estimated on good authority, that there are visible, by means of glasses, no less than one *hundred millions of stars*, scattered at all possible distances in the heavens above, beneath, and around us. Now, is it in the least degree probable, that the velocities of all these bodies should be so regulated, that, though describing circles so very different in dimensions, they should complete their revolutions in exactly the same time?

In short, there is no more reason to suppose that the heavens revolve around the earth, than there is to suppose that they revolve around each of the other planets, separately, and at the same time; since the same apparent revolution is common to them all, for they all appear to revolve upon their axes, in different periods.

The rotation of the earth determines the length of the day, and may be regarded as one of the most important elements in astronomical science. It serves as a universal measure of time, and forms the standard of comparison for the revolution of the celestial bodies, for all ages, past and to come. Theory and observation concur in proving, that among the innumerable vicissitudes that prevail throughout creation, the period of the earth's diurnal rotation is immutable.

The earth performs one complete revolution on its axis in 23 hours, 56 minutes, and 4.09 seconds, of solar time. This is called a *sidereal day*, because, in that time, the stars appear to complete one revolution around the earth.

But as the earth advances almost a degree eastward in its orbit, in the time that it turns eastward around its axis, it is plain that just one rotation never brings the same meridian around from the sun to the sun again; so that the earth requires as much more than one complete revolution on its axis to complete a *solar day*, as it has gone forward in that time. Hence in every natural or solar day, the earth performs one complete revolution on its axis, and the 365th part of another revolution. Consequently, in 365 days, the earth turns 366 times around its axis. And as every revolution of the earth on its axis completes a sidereal day, there must be 366 sidereal days in a year. And, generally, since the rotation of any planet about its axis is the length of a sidereal day at that planet, the number of sidereal days will always exceed the number of solar days, by one, let that number be what it may, one revolution being lost in the course of an annual revolution. This difference between the sidereal and solar days may be illustrated by referring to a watch or clock. When both hands set out together, at 12 o'clock for instance, the minute hand must travel more than a whole circle before it will overtake the hour hand, that is, before they will come into conjunction again.

In the same manner, if a man travel around the earth *eastwardly*, no matter in what time, he will reckon *one day more*, on his arrival at the place whence he set out, than they do who remain at rest; while the man who travels around the earth *westwardly* will have *one day less*. From which it is manifest, that, if two persons start from the same place at the same time, but go in contrary directions, the one traveling eastward and the other westward, and each goes completely around the globe, although they should both arrive again at the very same hour at the same place from which they set out, yet they will disagree two whole days in their reckoning. Should the day of their return, to the man who traveled westwardly, be Monday, to the man who traveled eastwardly, it would be Wednesday; while to those who remained at the place itself, it would be Tuesday.

Nor is it necessary, in order to produce the gain or loss of a day, that the journey be performed either on the equator, or on any parallel of latitude; it is sufficient for the purpose, that all the meridians of the earth be passed through, eastward or westward. The time, also, occupied in the journey, is equally unimportant; the gain or loss of a day being the same, whether the earth be traveled around in 24 years, or in as many hours.

It is also evident, that if the earth turned around its axis but once in a year, and if the revolution was performed the same way as its revolution around the sun, there would be perpetual day on one side of it, and perpetual night on the other.

From these facts the pupil will readily comprehend the principles involved in a curious problem which appeared a few years ago: It was gravely reported by an American ship, that, in sailing over the ocean, it chanced to find *six Sundays in February*. The *fact* was insisted on, and a solution demanded. There is nothing absurd in this.—The man who travels around the earth, *eastwardly*, will see the sun go down a little earlier every succeeding day, than if he had remained at rest; or earlier than they do who live at the place from which he set out. The faster he travels toward the rising sun, the sooner will it appear above the horizon in the morning, so much the sooner will it set in the evening. What he thus gains *in time*, will bear the same proportion to a solar day, as the distance traveled does to the circumference of the earth.—As the globe is 360° in circumference, the sun will appear to move over one twenty-fourth part of its surface, or 14° every hour, which is four minutes to *one degree.*—Consequently, the sun will rise, come to the meridian, and set, four minutes sooner, at a place 1° east of us, than it will with us; at the distance of 2°, the sun will rise and set eight minutes sooner; at the distance of 3°, twelve minutes sooner, and so on.

Now the man who travels one degree to the east, the first day, will have the sun on his meridian four minutes sooner than we do who are at rest; and the second day, eight minutes sooner, and on the third day, twelve minutes sooner, and so on; each successive day being completed four minutes earlier than the preceding, until he arrives again at the place from which he started; when this continual gain of four minutes a day will have amounted to a whole day *in advance* of our time; he having seen the sun rise and set *once more* than we have. Consequently, the day on which he arrives at home, whatever day of the week it may be, is one day in advance of ours, and he must needs live that day over again, by calling that day by the same name, in order to make the accounts harmonize.

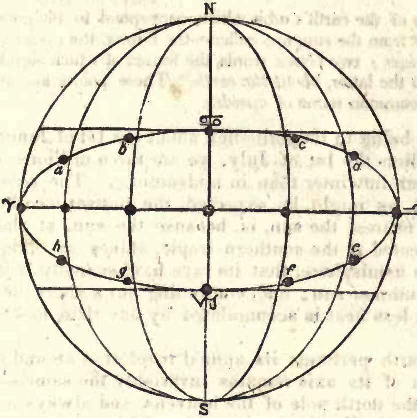
If this should be the last day of February in a bissextile year, it would also be the same day of the week that the *first* was, and be six times repeated; and if it should happen on Sunday, he would, under these circumstances, have six Sundays in February.

Again:—Whereas the man who travels at the rate of one degree to the east, will have all his days four minutes *shorter* than ours, so, on the contrary, the man who travels at the same rate toward the west, will have all his days four minutes *longer* than ours. When he has finished the circuit of the earth and arrived at the place from which he first set out, he will have seen the sun rise and set *once less* than we have. Consequently, the day he gets home will be *one day after* the time of that place: for which reason, if he arrives at home on Saturday, according to his own account, he will have to call the next day *Monday;* Sunday having gone by before he reached home. Thus, on whatever day of the week January should end, in common years, he would find the same day repeated only three times in February. If January ended on Sunday, he would, under these circumstances, find only *three Sundays in February.*

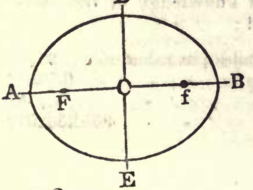
The earth's motion about its axis being perfectly equable and uniform in every part of its annual revolution, the sidereal days are always of the same length, but the solar or natural days vary very considerably at different times of the year. This variation is owing to two distinct causes: the inclination of the earth's axis to its orbit, and the inequality of its motion around the sun. From these two causes it is, that the time shown by a well regulated clock, and that of a true sun-dial, are scarcely ever the same. The difference between them, which sometimes amounts to 16¼ minutes, is called the *Equation of Time*, or the equation of solar days.

The difference between *mean* and *apparent* time, or, in other words, between *Equinoctial* and *Ecliptic* time, may be further shown by the figure which represents the circle of the sphere. Let it be first premised, that *equinoctial* time is *clock* time; and that *ecliptic* time is *solar* or *apparent* time. It appears that from Aries to Cancer, the sun in the ecliptic comes to the meridian *before* the equinoctial sun; from Cancer to Libra, *after* it; from Libra to Capricorn *before* it; and from Capricorn to Aries, *after* it. If we notice what months the sun is in these several quarters, we shall find that from the 25th of December to the 16th of April, and from the 16th of June to the 1st of September, the *clock is faster* than the sun-dial; and that, from the 16th of April to the 16th of June, and from the 1st of September to the 25th of December, the *sun-dial* is faster than the clock.

EQUATION OF TIME.



It is a universal fact, that, while none of the planets are perfect spheres, none of their orbits are perfect circles. The planets all revolve about the sun, in ellipses of different degrees of eccentricity; having the sun, not in the center of the ellipse, but in one of its foci.



The figure A D B E is an *ellipse.* The line A B is called the transverse axis, and the line drawn through the middle of this line, and perpendicular to it, is the conjugate axis. The point C, the middle of the transverse axis, is the *center* of the ellipse. The points F and f, equally distant from C, are called the *foci.* C F, the distance from the center to one of the foci, is called the eccentricity. The orbits of the planets being ellipses, having the sun in one of the foci, if A B D E be the orbit of a planet, with the sun in the focus F, when the planet is at the point A, it will be in its *perihelion*, or nearest the sun; and when at the point B, in its *aphelion*, or at its greatest distance from the sun. The difference in these distances is evidently equal to F f, that is, equal to twice the eccentricity of its orbit. In every revolution, a planet passes through its perihelion and aphelion. The eccentricity of the earth's orbit is about one and a half millions of miles: hence she is three millions of miles nearer the sun in her perihelion than in her aphelion.

Now, as the sun remains fixed in the lower focus of the earth's orbit, it is easy to perceive that a line, passing centrally through the sun at right angles with the longer axis of the orbit, will divide it into two unequal segments. *Precisely thus it is divided by the equinoctial.*

That portion of the earth's orbit which lies *above* the sun, or *north* of the equinoctial, contains about 184 degrees; while that portion of it which lies *below* the sun, or *south* of the equinoctial, contains only 176 degrees. This fact shows why the sun continues about eight days longer on the north side of the equator in summer, than it does on the south side in winter.

The points of the earth's orbit which correspond to its greatest and least distances from the sun, are called—the former, the *apogee*, and the latter, the *perigee;* two Greek words, the former of which signifies *from the earth*, and the latter, *about the earth*. These points are also designated by the common name of *apsides*.

The earth being in its perihelion about the 1st of January, and in its aphelion the 1st of July, we are three millions of miles nearer the sun in winter than in midsummer. The reason why we have not, as might be expected, the hottest weather when the earth is nearest the sun, is, because the sun, at that time, having retreated to the southern tropic, shines so obliquely on the northern hemisphere, that its rays have scarcely half the effect of the summer sun; and, continuing but a short time above the horizon, less heat is accumulated by day than is dissipated by night.

As the earth performs its annual revolution around the sun, the position of its axis remains invariably the same,—always pointing to the north pole of the heavens, and always maintaining the same inclination to its orbit. This seems to be providentially ordered for the benefit of mankind. If the axis of the earth always pointed to the center of its orbit, all external objects would appear to whirl about our heads in an inexplicable maze. Nothing would appear permanent. The mariner could no longer direct his course by the stars, and every index in nature would mislead us.

The following is a summary of our knowledge of the earth, as a planet; epoch, 1st January, 1801:

Mean distance from the sun (95,000,000 miles), its radius unity,	23984
Distance at perihelion, mean distance unity, - -	0.09832
Distance at aphelion, mean distance unity, -	1.0168
Mean sideral revolution, in solar days, -	365.2563612

Mean tropical revolution, in solar days,	365.2422414
Mean anomalistic revolution, in solar days,	365.2595981
Entire revolution of the sun's perigee, in solar days,	7.645,793
Mean longitude, corrected 20″ for aberration,	100° 39′ 10″.2
Motion in perihelion, in a mean solar day,	1 01 09 .9
Mean motion, in a mean solar day,	0 59 08 .33
Mean motion in a sidereal day,	0 58 58 .64
Motion in aphelion, in a mean solar day,	0 57 11 .5
Mean longitude of perihelion,	99 30 05 .0
E. motion of line of apsides, per annum,	11 .8
Ditto, referred to the ecliptic,	1 01 .9
Complete tropical revolution of apsides in years,	20,984
Obliquity of ecliptic,	23° 27′ 56″.5
Annual diminution of ditto,	0 .457
Semi axis major of nutation,	9 .4
Annual luni-solar precession,	50 .4
General precession in longitude,	50 .1
Complete revolution of equinoxes, in years,	25868
Lunar nutation in longitude,	17″.579
Solar nutation in longitude,	1 .137
Eccentricity of orbit, semi axis major as unity,	0.016783568
Decrease of ditto in 100 years,	0.00004163
Diurnal acceleration of sidereal or mean solar time,	3′ 55″.91
From the vernal equinox to the summer solstice,	92 d. 21 h. 50 m.
From the summer solstice to the autumnal equinox,	93 13 44
From the autumnal equinox to the winter solstice,	89 16 44
From the winter solstice to the vernal equinox,	89 01 33
Mass, sun as unity,	0.0000028173
Volume,	1.0
Density, sun as unity,	3.9326
Density, water as unity,	5.6747
Mean diameter (equatorial, 7924, polar, 7898), in miles,	7916
Centrifugal force at the equator,	0.00346
Time of passage of light from the sun,	8 m. 13 s. .3
Motion of earth, in orbit, in the same time.	20″.25

THE MOON.

There is no object within the scope of astronomical observation which affords greater variety of interesting investigation than the various phases and motions of the moon. From them, the astronomer ascertains the form of the earth, the vicissitudes of the tides, the causes of eclipses and occultations, the distance of the sun, and, consequently, the magnitude of the solar system. These phenomena, which are perfectly obvious to the unassisted eye, served as a standard of measurement to all nations, until the advancement of science taught them the advantages of solar time. It is to these phenomena that the navigator is indebted for that precision of knowledge which guides him with well-grounded confidence through the pathless ocean.

The Hebrews, the Greeks, the Romans, and, in general, all the ancients, used to assemble at the time of new or full moon, to discharge the duties of piety and gratitude, for her unwearied attendance on the earth, and all her manifold uses.

When the moon, after having been in conjunction with the sun, emerges from his rays, she first appears in the evening, a little after sunset, like a fine luminous crescent, with its convex side toward the sun. If we observe her the next evening, we find her about 13° further east of the sun than on the preceding evening, and her crescent of light sensibly augmented. Repeating these observations, we perceive that she departs further and further from the sun, as her enlightened surface comes more and more into view, until she arrives at her *first quarter*, and comes to the meridian at sunset. She has then finished her course from the new to the full, and half her enlightened hemisphere is turned toward the earth.

After her first quarter, she appears more and more *gibbous*, as she recedes further and further from the sun, until she has completed just half her revolution around the earth, and is seen rising in the east when the sun is setting in the west. She then presents her enlightened orb *full* to our view, and is said to be in *opposition;* because she is then on the opposite side of the earth with respect to the sun.

In the first half of her orbit, she appears to pass over our heads through the upper hemisphere; she now descends below the eastern horizon, to pass through that part of her orbit which lies in the lower hemisphere.

After her full, she wanes through the same changes of appearance as before, but in an inverted order; and we see her in the morning like a fine thread of light, a little west of the rising sun. For the next two or three days, she is lost to our view, rising and setting in *conjunction* with the sun; after which, she passes over, by reason of her daily motion, to the *east* side of the sun, and we behold her again a new moon, as before. In changing sides with the sun, she changes also the direction of her crescent. Before her conjunction, it was turned to the east; it is now turned toward the west. These different appearances of the moon are called her *phases*. They prove that she shines not by any light of her own; if she did, being globular, we should always see her a round, full orb, like the sun.

The moon is a satellite to the earth, about which she revolves, in an elliptical orbit, in 29 days, 12 hours, 44 minutes, and 3 seconds: the time which elapses between one new moon and another. This is called her *synodic* revolution. Her revolution from any fixed star to the same star again is called her *periodic* or *sidereal* revolution. It is accomplished in 27 days, 7 hours, 43 minutes, and 11½ seconds; but, in this time, the earth has advanced nearly as many *degrees* in her orbit, consequently, the moon, at the end of one complete revolution, must go as many degrees further, before she will come again into the same position with respect to the sun and the earth.

The moon is the nearest of all the heavenly bodies, being 30 times the diameter of the earth, or 240,000 miles, distant from us. Her mean daily motion, in her orbit, is nearly 14 times as great as the earth's; since she not only accompanies the earth around the sun every year, but, in the meantime, performs nearly 13 revolutions about the earth.

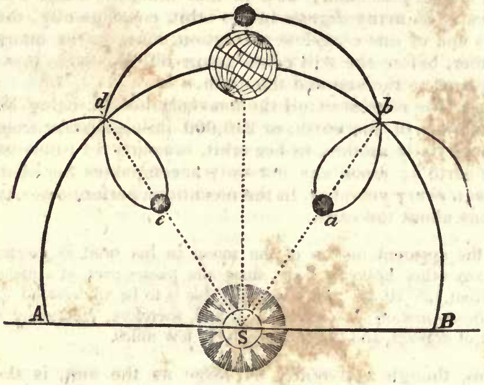
Although the apparent motion of the moon in her orbit, is greater than that of any other heavenly body, since she passes over, at a mean rate, no less than $13^{\circ}\ 10'\ 35''$ in a day; yet this is to be understood as *angular motion*—motion in a small orbit, and, therefore, embracing a great number of *degrees*, and but comparatively few miles.

The moon, though apparently as l[illegible] as the sun, is the smallest of all the heavenly bodies that are visible to the naked eye. Her diameter is but 2162 miles; consequently, her surface is 13 times less than that of the earth, and her bulk 49 times less. It would require 70,000,000 of such bodies to equal the volume of the sun. The reason why she appears as large as the sun, when, in truth, she is so much less, is because she is 400 times nearer to us than the sun.

The moon revolves once on her axis, exactly in the time that she performs her revolution around the earth. This is evident from her always presenting the same side to the earth; for if she had no rotation upon an axis, every part of her surface would be presented to a spectator on the earth, in the course of her synodical revolution. It follows, then, that there is but *one day and night in her year*, containing, both together, 29 days, 12 hours, 44 minutes, and 3 seconds.

As the moon, while revolving about the earth, is carried with it at the same time around the sun, her path is extremely irregular, and very different from what it seems to be. Like a point in the wheel of a carriage, moving over a convex road, the moon will describe a succession of epicycloidal curves, which are always concave toward the sun, not very unlike their presentation in the following figure.

THE MOON'S MOTION.



Let *A d b B* represent a portion of the earth's orbit; and *a b c d e* the lunar orbit. When the earth is at *b*. the new moon is at *a*; and while the earth is moving from *b*. to its position as represented in the figure, the moon has moved through half her orbit, from *a* to *c*, where she is full; so, while the earth is moving from its present position to *d*, the moon describes the other half of her orbit from *c* to *e*, where she is again in conjunction.

As the moon turns on her axis only as she moves around the earth, it is plain that the inhabitants of one half of the lunar world are totally deprived of the sight of the earth, unless they travel to the opposite hemisphere. This we may presume they will do, were it only to view so sublime a spectacle; for it is certain that, from the moon, the earth appears *ten times larger* than any other body in the universe.

As the moon enlightens the earth, by reflecting the light of the sun, so likewise the earth illuminates the moon, exhibiting to her the same phases that she does to us, only in a contrary order. And, as the surface of the earth is 13 times as large as the surface of the moon, the earth, when full to the moon, will appear 13 times as large as the full moon to us. That side of the moon, therefore, which is toward the earth, may be said to have no darkness at all, the earth constantly shining upon it with extraordinary splendor when the sun is absent; it therefore enjoys successively two weeks of illumination from the sun, and two weeks of earth-light from the earth. The other side of the moon has alternately a fortnight's light, and a fortnight's darkness.

As the earth revolves on its axis, the several continents, seas, and islands, appear to the lunar inhabitants like so many spots, of different forms and brightness, alternately moving over its surface, being more or less brilliant, as they are seen through intervening clouds. By these spots, the lunarians can not only determine the period of the earth's rotation, just as we do that of the sun, but they may also find the longitude of their places, as we find the latitude of ours.

As the full moon always happens when the moon is directly opposite the sun, all the full moons in our *winter*, must happen when the moon is on the *north* side of the equinoctial, because *then* the sun is on the *south* side of it; consequently, at the north pole of the earth, there will be a fortnight's moon-light and a fortnight's darkness by turns, for a period of six months, and the same will be the fact during the sun's absence the other six months, at the south pole.

The moon's axis being inclined only about $1\frac{1}{2}°$ to her orbit, she can have no sensible diversity of seasons; from which we may infer, that her atmosphere is mild and uniform. The quantity of light which we derive from the moon when full, is at least three hundred thousand times less than that of the sun.*

When viewed through a good telescope, the moon presents a most wonderful and interesting aspect. Besides the large dark spots, which are visible to the naked eye, we perceive extensive valleys, shelving rocks, and long ridges of elevated mountains, projecting their shadows on the plains below. Single mountains occasionally rise to a great hight, while circular hollows, more than *three miles* deep, seem excavated in the plains.

Her mountain scenery bears a striking resemblance to the towering sublimity and terrific ruggedness of the Alpine regions, or of the Appenines, after which some of her mountains have been named, and of the Cordilleras of our own continent.—Huge masses of rock rising precipitously from the plains, lift their peaked summits to an immense hight in the air, while shapeless crags hang over their projecting sides, and seem on the eve of being precipitated into the tremendous chasm below.

Around the base of these frightful eminences, are strewed numerous loose and unconnected fragments, which time seems to have detached from their parent mass; and when we examine the rents and ravines which accompany the overhanging cliffs, the beholder expects every moment that they are to be torn from their base, and that the process of destructive separation which he had only contemplated in its effects, is about to be exhibited before him in all its reality.

* This is Mons. Bouquer's inference, from his experiments, as stated by La Place, in his work, p, 42. The result of Dr. Wollaston's computations was different. Professor Leslie makes the light of the moon 150.000 times less than that of the sun: it was formerly reckoned 100,000 times less.

The range of mountains called the Appenines, which traverses a portion of the moon's disk from north-east to south-west, and of which some parts are visible to the naked eye, rise with a precipitous and craggy front from the level of the *Mare Imbrium*, or Sea of showers.* In this extensive range are several ridges whose summits have a perpendicular elevation of four miles, and more; and though they often descend to a much lower level, they present an inaccessible barrier on the north-east, while on the south-west they sink in gentle declivity to the plains.

There is one remarkable feature in the moon's surface, which bears no analogy to any thing observable on the earth. This is the circular cavities which appear in every part of her disk. Some of these immense caverns are nearly four miles deep, and forty miles in diameter. They are most numerous in the south-western part. As they reflect the sun's rays more copiously, they render this part of her surface more brilliant than any other. They present to us nearly the same appearance as our earth might be supposed to present to the moon, if all our great lakes and seas were dried up.

The number of remarkable spots on the moon, whose latitude and longitude have been accurately determined, exceeds two hundred. The number of seas and lakes, as they were formerly considered, whose length and breadth are known, is between twenty and thirty; while the number of peaks and mountains, whose perpendicular elevation varies from a fourth of a mile to five miles in hight, and whose bases are from one to seventy miles in length, is not less than one hundred and fifty.†

Graphical views of these natural appearances, accompanied with minute and familiar descriptions, constitute what is called *Selenography*, from two Greek words, which mean the same thing in regard to the moon, as *Geography* does in regard to the earth.

An idea of some of these scenes may be formed by conceiving a plain of about a hundred miles in circumference, encircled by a range of mountains, of various forms, three miles in perpendicular hight, and having a mountain near the center, whose top reaches a mile and a half above the level of the plain. From the top of this central mountain, the whole plain, with all its scenery, would be distinctly visible, and the view would be bounded only by a lofty amphitheater of mountains, rearing their summits to the sky.

* The name of a lunar spot.

† Brewster's *Selenography*. The best maps of the moon hitherto published are those by Mädler and Beer; but the most curious and complete representation of the telescopic and natural appearances of the moon, is to be seen on Russel's *Lunar Globe*. See also *Selenographia*, by C. Blunt.

The bright spots of the moon are the mountainous regions; while the dark spots are the plains, or more level parts of her surface. There may be rivers or small lakes on this planet; but it is generally thought, by astronomers of the present day, that there are no seas or large collections of water, as was formerly supposed. Some of these mountains and deep valleys are visible to the naked eye; and many more are visible through a telescope of but moderate powers.

A telescope which magnifies only a hundred times, will show a spot on the moon's surface, whose diameter is twelve hundred and twenty-three yards; and one which magnifies a thousand times, will enable us to perceive any enlightened object on her surface whose dimensions are only a hundred and twenty-two yards, which does not much exceed the dimensions of some of our public edifices, as for instance, the Capitol at Washington, or St. Paul's Cathedral. Professor Frauenhofer, of Munich, recently announced that he had discovered a lunar edifice, resembling a *fortification*, together with *several lines of road.* The celebrated astronomer Schroeter, conjectures the existence of a great city on the east side of the moon, a little north of her equator, an extensive canal in another place, and fields of vegetation in another. But no reliance is to be placed on these conjectures.

SOLAR AND LUNAR ECLIPSES.

Of all the phenomena of the heavens, there are none which engage the attention of mankind more than eclipses of the sun and moon; and to those who are unacquainted with astronomy, nothing appears more wonderful than the accuracy with which they can be predicted. In the early ages of antiquity they were regarded as alarming deviations from the established laws of nature, presaging great public calamities, and other tokens of the divine displeasure.

In China, the prediction and observance of eclipses are made a matter of state policy, in order to operate on the fears of the ignorant, and impose on them a superstitious regard for the occult wisdom of their rulers. In Mexico, the natives fast and afflict themselves during eclipses, under an apprehension that the Great Spirit is in deep sufferance. Some of the northern tribes of Indians have imagined that the moon had been wounded in a quarrel; and others, that she was about to be swallowed by a huge fish.

It was by availing himself of these superstitious notions that Columbus, when shipwrecked on the island of Jamaica, extricated himself and crew from a most embarrassing condition. Being driven to great distress for want of provisions, and the natives refusing him any assistance, when all hope seemed to be cut off, he bethought himself of their superstition in regard to eclipses. Having assembled the principal men of the island, he remonstrated against their inhumanity, as being offensive to the Great Spirit, and told them that a great plague was even then ready to fall upon them, and as a token of it, they would that night see the moon hide her face in anger, and put on a dreadfully dark and threatening aspect. This artifice had the desired effect; for the eclipse had no sooner begun than the frightened barbarians came running with all kinds of provisions, and throwing themselves at the feet of Columbus, implored his forgiveness.—*Almagest*, vol. I, 55 c., v. 2.

An eclipse of the sun takes place, when the dark body of the moon passing directly between the earth and the sun, intercepts his light. This can happen only at the instant of *new* moon, or when the moon is in conjunction; for it is only then that she passes between us and the sun.

An eclipse of the moon takes place when the dark body of the earth, coming between her and the sun, intercepts his light, and throws a shadow on the moon. This can happen only at the time of *full* moon, or when the moon is in opposition; for it is only then that the earth is between her and the sun.

As every planet belonging to the solar system, both primary and secondary, derives its light from the sun, it must cast a shadow toward that part of the heavens which is opposite to the sun. This shadow is of course nothing but a privation of light in the space hid from the sun by the opake body, and will be proportioned to the magnitude of the sun and planet.

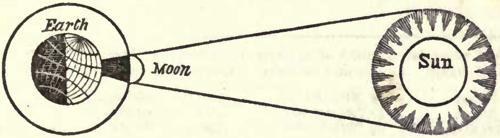
If the sun and planet were both of the same magnitude, the form of the shadow cast by the planet, would be that of a cylinder, and of the same diameter as the sun or planet. If the planet were *larger* than the sun, the shadow would continually diverge, and grow larger and larger; but as the sun is much larger than any of the planets, the shadows which they cast must converge to a point in the form of a cone; the length of which will be proportional to the size and distance of the planet from the sun.

The magnitude of the sun is such, that the shadow cast by each of the primary planets always converges to a point before it reaches any other planet; so that not one of the primary planets can eclipse another. The shadow of any planet which is accompanied by satellites, may, on certain occasions, eclipse its satellites; but it is not long enough to eclipse any other body. The shadow of a satellite, or moon, may also, on certain occasions, fall on the primary, and eclipse it.

When the sun is at his *greatest* distance from the earth, and the moon at her *least* distance, her shadow is sufficiently long to reach the earth, and extend 19,000 miles beyond. When the sun is at his *least* distance from the earth, and the moon at her *greatest,* her shadow will not reach the earth's surface by 20,000 miles. So that when the sun and moon are at their *mean* distances, the cone of the moon's shadow will terminate a little before it reaches the earth's surface.

In the former case, if a conjunction take place when the center of the moon comes in a direct line between the centers of the sun and earth, the dark shadow of the moon will fall centrally upon the earth, and cover a circular area of 175 miles in diameter. To all places lying within this dark spot, the sun will be totally eclipsed, as illustrated by the figure.

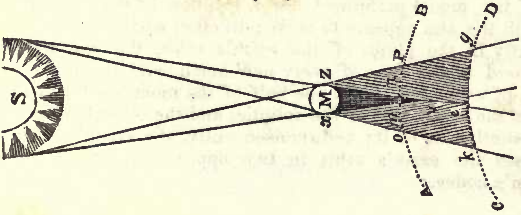
ECLIPSES OF THE SUN.



In consequence of the earth's motion during the eclipse, this circular area becomes a continued belt over the earth's surface; being, at the broadest, 175 miles wide. This belt is, however, rarely so broad, and often dwindles to a mere nominal line, without total darkness.

In March, this line extends itself from S. W. to N. E., and in September, from N. W. to S. E. In June, the central line is a curve, going first to the N. E., and then to the S. E.; in December, on the contrary, first to the S. E., and then to the N. E. To all places within 2000 miles, at least, of the central line, the eclipse will be visible; and the nearer the place of observation is to the line, the larger will be the eclipse. In winter, if the central trace be but a little northward of the equator, and in summer, if it be 25° N. latitude, the eclipse will be visible all over the northern hemisphere. As a general rule, though liable to many modifications, we may observe, that places from 200 to 250 miles from the central line, will be 11 digits eclipsed; from thence to 500 miles, 10 digits; and so on, diminishing one digit in about 250 miles.

If, in either of the other cases, a conjunction take place when the moon's center is directly between the centers of the sun and earth, as before, the moon will then be too distant to cover the entire face of the sun, and there will be seen, all around her dark body, a slender ring of dazzling light.



This may be illustrated by the foregoing figure. Suppose *C D* to represent a part of the earth's orbit, and the moon's shadow to terminate at the vertex V. The small space between *e f* will represent the breadth of the luminous ring which will be visible all around the dark body of the moon.

Such was the eclipse of February 12, 1831, which passed over the southern states from S. W. to N. E. It was the first annular eclipse ever visible in the United States. Along the path of this eclipse, the luminous ring remained perfect and unbroken for the space of two minutes

From the most elaborate calculations, compared with a long series of observations, the length of the moon's shadow in eclipses, and her distance from the sun at the same time, vary within the limits of the following table:

Length of shadow, Dist. of moon.	Length of shadow in semidiameters.	Length in miles.	Distance in semidiameters.	Distance in miles.
Least	57.760×3956=	228.499	55.902×3956=	221.148
Mean	58.728×3956=	232.328	60.238×3956=	238.300
Greatest	59.730×3956=	236,292	63.862×3956=	252,638

Thus it appears that the length of the cone of the moon's shadow, in eclipses, varies from 228,499 to 236,292 miles; being 7,793 miles longer in the one case, than in the other. The inequality of her distances from the earth is much greater; they vary from 221,148 to 252,638 miles, making a difference of 31,490 miles.

Although a central eclipse of the sun can never be total to any spot on the earth more than 175 miles broad; yet the space over which the sun will be more or less *partially* eclipsed, is nearly 5000 miles broad.

The section of the moon's shadow, or her penumbra, at the earth's surface, in eclipses, is far from being always circular. If the conjunction happen when the center of the moon is a little *above* or a little *below* the line joining the centers of the earth and sun, as is most frequently the case, the shadow will be projected *obliquely* over the earth's surface, and thus cover a much larger space.

To produce a partial eclipse, it is not necessary that the shadow should reach the earth; it is sufficient that the apparent distance between the sun and moon be not greater than the sum of their semidiameters.

If the moon performed her revolution in the same path in which the sun appears to move; in other words, if her orbit lay exactly in the plane of the earth's orbit, the sun would be eclipsed at the time of every new moon, and the moon at the time of every full. But one half of the moon's orbit lies about 5° on the north side of the ecliptic, and the other half as far on the south side of it; and, consequently, the moon's orbit only crosses the earth's orbit in two opposite points, called the moon's nodes.

When the moon is in one of these points, or nearly so, at the time of the *new* moon, the sun will be eclipsed. When she is in one of them, or nearly so, at the time of *full* moon, the moon will be eclipsed. But at all other new moons, the moon either passes above or below the sun, as seen from the earth; and, at all other full moons, she either passes above or below the earth's shadow; and, consequently, there can be no eclipse.

If the moon be *exactly* in one of her nodes at the time of her change, the sun will be centrally eclipsed. If she be 1½° from her node at the time of her change, the sun will appear at the equator to be about 11 digits eclipsed. If she be 3° from her node at the time of her change, the sun will be 10 digits eclipsed, and so on; a digit being the twelfth part of the sun's diameter. But when the moon is about 18° from her node, she will just touch the outer edge of the sun, at the time of her change, without producing any eclipse. These are called the *ecliptic limits.* Between these limits, an eclipse is doubtful, and requires a more exact calculation.

The mean ecliptic limit for the sun is 16½° on each side of the node; the mean ecliptic limit for the moon is 10½° on each side of the node. In the former case, then, there are 33° about each node, making, in all, 66° out of 360°, in which eclipses of the sun may happen: in the latter case, there are 21° about each node, making, in all, 42° out of 360°, in which eclipses of the moon usually occur. The proportion of the solar to the lunar eclipses, therefore, is as 66 to 42, or as 11 to 7. Yet there are more visible eclipses of the moon, at any given place, than of the sun; because a lunar eclipse is visible to a whole hemisphere, a solar eclipse only to a small portion of it.

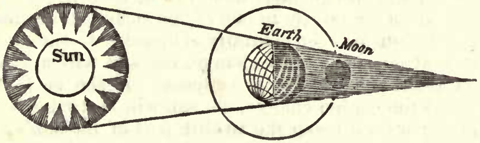
The greatest possible duration of the annular appearance of a solar eclipse, is 12 minutes and 24 seconds; and the greatest possible time during which the sun can be totally eclipsed, to any part of the world, is 7 minutes and 58 seconds. The moon may continue totally eclipsed for one hour and three quarters.

Eclipses of the sun always begin on his western edge, and end on his eastern; but all eclipses of the moon commence on her eastern edge, and end on her western.

If the moon, at the time of her opposition, be exactly in her node, she will pass through the center of the earth's shadow, and be totally eclipsed. If, at the time of her opposition, she be within 6° of her node, she will still pass through the earth's shadow, though not centrally, and be totally eclipsed: but if she be 12° from her node, she will only just touch the earth's shadow, and pass it without being eclipsed.

The duration of lunar eclipses, therefore, depends upon the difference between the diameter of the moon and that section of the earth's shadow through which she passes. When an eclipse of the moon is both total and central, its duration is the longest possible, amounting nearly to 4 hours; but the duration of all eclipses *not* central varies with her distance from the node.

ECLIPSES OF THE MOON.



The *diameter* of the earth's shadow, at the distance of the moon, is nearly three times as large as the diameter of the moon; and the *length* of the earth's shadow is nearly four times as great as the distance of the moon; exceeding it in the same ratio that the diameter of the earth does the diameter of the moon, which is as 3.663 to 1.

The length of the earth's shadow, and its diameter at the distance of the moon, are subject to the variations exhibited in the following table:		Diameter of the shadow.	Length of the shadow in ms.
Sun at the perigee	Moon at the apogee	5.232	842,217
	Moon at her mean distance	5.762	
	Moon at the perigee	6,292	
Sun at his mean distance	Moon at the apogee	5.270	856.597
	Moon at her mean distance	5,799	
	Moon at the perigee	6.329	
Sun at the apogee	Moon at the apogee	5.306	871,262
	Moon at her mean distance	5.836	
	Moon at the perigee	6 365	

The first column of figures expresses the diameter of the earth's shadow at the moon: and as the diameter of the moon is only 2162 miles, it is evident that it can always be comprehended by the shadow, which is more than twice as broad as the disk of the moon.

The time which elapses between two successive changes of the moon, is called a *Lunation*, which, at a mean rate, is about 29½ days. If 12 lunar months were exactly equal to the 12 solar months, the moon's nodes would always occupy the same points in the ecliptic, and all eclipses would happen in the same months of the year, as is the case with the transits of Mercury and Venus: but, in 12 lunations, or lunar months, there are only 354 days; and in this time the moon has passed through both her nodes, but has not quite accomplished her revolution around the sun: the consequence is, that the moon's nodes fall back in the ecliptic at the rate of about 19½° annually; so that the eclipses happen sooner every year by about 19 days.

As the moon passes from one of her nodes to the other in 173 days, there is just this period between two successive eclipses of the sun, or of the moon. In whatever time of the year, then, we have eclipses at either node, we may be sure that in 173 days afterwards, we shall have eclipses at the other node.

As the moon's nodes fall back, or retrograde in the ecliptic, at the rate of 19½° every year, they will complete a backward revolution entirely around the ecliptic to the same point again, in 18 years 225 days; in which time there would always be a regular period of eclipses, if any complete number of lunations were finished without a remainder. But this never happens; for if both the sun and moon should start from a line of conjunction with either of the nodes in any point of the ecliptic, the sun would perform 18 annual revolutions and 222° of another, while the moon would perform 230 lunations, and 85° of another, before the node would come around to the same point of the ecliptic again; so that the sun would then be 138° from the node, and the moon 85° from the sun.

But after 223 lunations, or 18 years 11 days,* 7 hours, 42 minutes, and 31 seconds, the sun, moon, and earth, will return so nearly in the same position with respect to each other, that there will be a *regular return of the same eclipses for many ages.* This grand period was discovered by the Chaldeans, and by them called *Saros.* If, therefore, to the mean time of any eclipse, either of the sun or moon, we add the Chaldean period of 18 years and 11 days, we shall have the return of the same eclipse. This mode of predicting eclipses will hold good for a thousand years. In this period there are usually 70 eclipses; 41 of the sun, and 29 of the moon.

The number of eclipses in any one year, cannot be less than two, nor more than seven. In the former case, they will both be of the sun; and in the latter, there will be five of the sun, and two of the moon—those of the moon will be total. There are sometimes six; but the usual number is four: two of the sun, and two of the moon.

The cause of this variety is thus accounted for. Although the sun usually passes by both nodes only once in a year, he may pass the same node again a little before the end of the year. In consequence of the retrograde motion of the moon's nodes, he will come to either of them 173 days after passing the other. He may, therefore, return to the same node in about 346 days, having thus passed one node *twice* and the other *once*, making each time, at each, an eclipse of both the sun and the moon, or *six* in all. And, since 12 lunations, or 354 days from the *first* eclipse in the *beginning* of the year, leave room for another new moon before the close of the year, and since this new moon may fall within the ecliptic limit, it is possible for the sun to be eclipsed again. Thus there may be *seven* eclipses in the same year.

Again: when the moon changes in either of her nodes, she cannot come within the lunar ecliptic limit at the next full, (though if she be

*If there are *four* leap years in this interval, add 11 days; but if there are *five*, add only ten days.

full in one of her nodes, she may come into the *solar* ecliptic limit at her next *change*, and six months afterwards, she will change near the other node; thus making only two eclipses.

The following is a list of all the solar eclipses that will be visible in Europe and America during the remainder of the present century.

Year.	Month.	Day and hour.	Digits	Year.	Month.	Day and hour.	Digits.
1848	Mar.	5 7 50 A. M.	$6\frac{1}{6}$	1876	Mar.	25 4 11 P. M.	$3\frac{3}{5}$
1851	July	28 7 48 A. M	$3\frac{2}{3}$	1878	July	29 4 56 P. M.	$7\frac{1}{4}$
1854	May	26 4 26 P. M.	$11\frac{1}{3}$	1879	July	19 2 0 A. M.	
1858	Mar.	15 6 14 A. M.	$1\frac{2}{3}$	1880	Dec.	31 7 30 A. M.	$5\frac{1}{3}$
1859	July	29 5 32 P. M.	$2\frac{1}{3}$	1882	May	17 1 0 A. M.	
1860	July	18 7 23 A. M	$6\frac{1}{3}$	1885	Mar	16 0 35 A. M.	$6\frac{1}{3}$
1861	Dec.	31 7 30 A. M	$4\frac{1}{2}$	1886	Aug.	29 6 30 A. M.	$0\frac{1}{4}$
1863	May	17 1 0 P. M.		1887	Aug.	18 10 0 P. M.	
1865	Oct.	19 9 10 A. M.	$3\frac{3}{5}$	1890	June	17 3 0 A. M.	
1866	Oct.	8 11 12 A. M.	0	1891	June	6 0 0 Mer.	
1867	Mar.	6 3 0 A M.		1892	Oct.	20 0 19 P. M.	$8\frac{1}{5}$
1868	Feb.	23 10 0 A M.		1895	Mar.	26 4 0 A. M.	
1869	Aug.	7 5 21 A. M.	$10\frac{1}{4}$	1896	Aug.	9 0 0 Mer.	
1870	Dec.	22 6 0 A. M.		1897	July	29 9 8 A. M.	$4\frac{1}{2}$
1873	May	26 3 0 A. M.		1899	June	8 0 0 Mer.	
1874	Oct.	10 4 0 A. M		1900	May	28 8 9 A. M.	11
1875	Sept.	29 5 56 A. M.	$11\frac{1}{2}$				

The eclipses of 1854, 1869, 1875, and 1900, will be very large. In those of 1858, 1861, 1873, 1875, and 1880, the *sun will rise eclipsed.*

Those of 1854 and 1875, will be *annular*. The scholar can continue this table, or extend it backward, by adding or subtracting the Chaldean period of 18 years, 11 days, 7 hours, 54 minutes and 31 seconds.

The lunar elements for the 1st of Jan. 1801, are as follows:

Mean distance (237,000 miles) earth eq. diam. as unity,	29.982175
Mean sidereal revolution, solar days, -	27 d. 7 h. 43 m. 11.5 s.
Mean tropical " " " -	27 7 43 04.7
Mean synodical " " " -	29 12 44 02.87
Mean longitude, - - - -	118° 17′ 08″.3
Mean motion in a mean solar day, - -	13 10 35 .0
Mean long. of perigee, - - - -	266° 10′ 7″.5
Mean motion of apsides, in a solar day, -	6′ 41″.0
Sidereal rev. of apsides, in mean solar days, - -	3232.5753
Tropical revolution of ditto, - - -	3231.4751
Mean anomaly, - - - -	212° 6′ 59″.9
Motion of ditto, in a mean solar day, - -	13°.064992
Mean anomalistic revolution, in solar days	27 d. 13 h. 18 m. 37.4 s.
Inclination of orbit, - - - -	5° 8′ 47″.9
Ascending node, - - - -	13 53 17 .7
Motion of ditto, in a mean solar day, - -	3 10 .6
Sidereal revolution of nodes, - - -	6793.39108
Synodical revolution of ditto, - - -	346.619851
Revolution from node to node, - -	27 d. 5 h. 5 m. 36 s.
Eccentricity of orbit, - - - -	0.0548442
Greatest equation of center, - - -	6° 17′ 12″.7

Inclination of axis,	1° 30′ 10″.8
Maximum evection,	1 20 29 .9
Maximum variation,	35 42 .0
Maximum annual equation,	11 12 .0
Minimum horizontal parallax,	53 48 .0
Mean ditto,	57 00 .9
Maximum ditto,	1 01 24 .0
Maximum app. diam.,	33 31 .1
Mean ditto,	31 07 .0
Minimum ditto,	29 21 .9
Mean diameter (about 2160 miles) earth's as unity,	3.665
Volume, earth as unity,	$\frac{1}{49}$
Mass,	0.01252
Density,	0.615

MARS.

MARS is the first of the exterior planets, its orbit lying immediately without, or *beyond*, that of the earth, while those of Mercury and Venus are *within*.

Mars appears to the naked eye, of a fine ruddy complexion; resembling, in color, and apparent magnitude, the star Antares, near which it frequently passes. It exhibits its greatest brilliancy about the time that it rises when the sun sets, and sets when the sun rises; because it is then nearest the earth. It is least brilliant when it rises and sets with the sun; for then it is five times farther removed from us than in the former case.

Its distance from the earth at its nearest approach is about fifty millions of miles. Its greatest distance from us is about two hundred and forty millions of miles. In the former case, it appears nearly twenty-five times larger than in the latter. When it rises before the sun, it is our morning star; when it sets after the sun, it is our evening star.

The distance of all the planets from the earth, whether they be interior or exterior planets, varies within the limits of the diameters of their orbits; for when a planet is in that point of its orbit which is nearest the earth, it is evidently nearer by the whole diameter of its orbit, than when it is in the opposite point, on the other side of its orbit. The *apparent diameter* of the planet will also vary for the same reason, and to the same degree.

Mars is sometimes seen in opposition to the sun, and sometimes in superior conjunction with him; sometimes gibbous, but never horned. In conjunction, it is never seen to pass over the sun's disk, like Mercury and Venus. This proves not only that its orbit is *exterior* to the earth's orbit, but that it is an opake body, shining only by the reflection of the sun.

The motion of Mars through the constellations of the zodiac is but little more than *half* as great as that of the earth; it being generally about fifty-seven days in passing over one sign, which is at the rate of a little more than half a degree each day. Thus, if we know what constellation Mars enters to day, we may conclude that two months hence it will be in the next constellation; four months hence, in the next; six months, in the next, and so on.

Mars performs his revolution around the sun in one year and ten and a half months, at the distance of a hundred and forty-five millions of miles; moving in its orbit at the mean rate of fifty-five thousand miles an hour. Its diurnal rotation on its axis is performed in twenty-four hours, thirty-seven minutes, and twenty-one and a third seconds; which makes its day about forty-four minutes longer than ours.

Its mean *sidereal* revolution is performed in 686.9796458 solar days; or in 686 days, 23 hours, 30 minutes, 41.4 seconds. Its *synodical* revolution is performed in 779.936 solar days; or in 779 days, 22 hours, 27 minutes, and 60 seconds.

Its form is that of an oblate spheroid, whose polar diameter is to its equatorial, as fifteen is to sixteen, nearly. Its mean diameter is 4222 miles. Its bulk, therefore, is seven times less than that of the earth; and being fifty millions of miles farther from the sun, it receives from him only half as much light and heat.

The inclination of its axis to the plane of its orbit, is about $28\frac{2}{3}°$. Consequently, its seasons must be very similar to those of the earth. Indeed, the analogy between Mars and the earth is greater than the analogy between the earth and any other planet of the solar system. Their diurnal motion, and of course the length of their days and nights, are nearly the same; the obliquity of their ecliptics, on which the seasons depend, are not very different; and, of all the superior planets, the distance of Mars from the sun is by far the nearest to that of the earth; nor is the length of its year greatly different from ours, when compared with the years of Jupiter, Saturn, and Herschel.

To a spectator on this planet, the earth will appear alternately, as a morning and evening star; and will exhibit all the phases of the moon, just as Mercury and Venus do to us; and sometimes, like them, will appear to pass over the sun's disk like a dark round spot. Our moon will never appear more than *a quarter of a degree* from the earth, although her distance from it is 240,000 miles. If Mars be attended by a satellite, it is too small to be seen by the most powerful telescopes.

When it is considered that Vesta, the smallest of the asteroids, which is *once and a half* times the distance of Mars from us, and only 269 miles in diameter, is perceivable in the open space, and that without the presence of a more conspicuous body to point it out, we may reasonably conclude that Mars is without a moon.

The progress of Mars in the heavens, and indeed of all the superior planets, will, like Mercury and Venus, sometimes appear direct, sometimes retrograde, and sometimes he will seem stationary. When a superior planet first becomes visible in the morning, west of the sun, a little after its conjunction, its motion is *direct*, and also most rapid. When it is first seen east of the sun, in the evening, soon after its opposition, its motion is *retrograde*. These retrograde movements and stations, as they appear to a spectator from the earth, are common to all the planets, and demonstrate the truth of the Copernican system.

The telescopic phenomena of Mars afford peculiar interest to astronomers. They behold its disk diversified with numerous irregular and variable spots, and ornamented with zones and belts of varying brilliancy, that form, and disappear, by turns. Zones of intense brightness are to be seen in its polar regions, subject, however, to gradual changes. That of the southern pole is much the most brilliant. Dr. Herschel supposes that they are produced by the reflection of the sun's light from the frozen regions, and that the melting of these masses of polar ice is the cause of the variation in their magnitude and appearance.

He was the more confirmed in these opinions by observing, that after the exposure of the luminous zone about the north pole to a summer of eight months, it was considerably *decreased*, while that on the south pole, which had been in total darkness during eight months, had considerably *increased*.

He observed, further, that when this spot was most luminous, the disk of Mars did not appear exactly *round*, and that the bright part of its southern limb seemed to be swollen or arched out beyond the proper curve.

The extraordinary hight and density of the atmosphere of Mars, are supposed to be the cause of the remarkable redness of its light.

It has been found by experiment, that when a beam of white light passes through any colorless transparent medium, its color inclines to red, in proportion to the density of the medium, and the space through which it has traveled. Thus the sun, moon, and stars, appear of a reddish color when near the horizon; and every luminous object, seen through a mist, is of a ruddy hue.

This phenomenon may be thus explained:—The momentum of the red, or least refrangible rays, being greater than that of the violet, or most refrangible rays, the former will make their way through the resisting medium, while the latter are either reflected or absorbed. The color of the *beam*, therefore, when it reaches the eye, must partake of the color of the least refrangible rays, and this color must increase with the distance. The dim light, therefore, by which Mars is illuminated, having to pass *twice* through its atmosphere before it reaches the earth, must be deprived of a great proportion of its violet rays, and consequently then be red. Dr. Brewster supposes that the difference of color among the other planets, and even the fixed stars, is owing to the different hights and densities of their atmospheres.

The elliptical elements of Mars, for Jan. 1st, 1801, are as follows:

Mean distance (142,000,000 miles), earth's as unity,	1.5236923
Mean sid. rev.,	686 d. 23 h. 30 m. 41.4 s.
Mean syn. do., in solar days,	779.936
Long. of perihelion.	332° 23′ 56″.6
Motion of apsides, E. per. an.,	15″.8
" apparent for precession,	1′ 05″.9
Inclination of orbit,	1° 51′ 06″.2
Annual decrease of do.,	0″.014
Long. of Asc. node,	48° 0′ 03″.5
Motion of do. W. per annum,	23″.3
" " " E. referred to the ecliptic,	26″.8
Eccentricity of orbit. Semi maj. axis unity,	0.0933070
Secular increase of do.,	0.00090176
Greatest equation of center,	10° 40′ 50″
Annual decrease of do.,	0″.37
Rotation on axis.	24 h. 37 m. 20.6 s.
Inclination of axis,	30° 18′ 10″.8
Mean app. diam.,	6″.29
Diam. at conjunction,	3″.60
" " opposition,	18.28
True diam. (4100 miles), earth as unity,	0.517
Volume, earth as unity,	0.1386
Mass, sun as unity,	0.0000003927

THE ASTEROIDS, OR TELESCOPIC PLANETS.

Ascending higher in the solar system, we find, between the orbits of Mars and Jupiter, a cluster of nine small planets, which present a variety of anomalies that distinguish them from all the older planets of the system. They were all discovered within the present century.

The dates of their discovery, and the names of their discoverers, are as follows:

Ceres, January 1, 1801, by M. Piazzi, of Palermo.
Pallas, March 28, 1802, by M. Olbers, of Bremen.
Juno, September 1, 1804, by M. Harding, of Bremen.
Vesta, March 29, 1807, by M. Olbers, of Bremen.
Astrea, 8th December, 1845, by Hencke, of Dreisen.
Hebe, 5th July, 1847, " " " "
Iris, 13th August, 1847, by Hind, of London.
Flora, 18th Oct., 1847, " " " "
Metis, 25th April, 1848, by Graham, of Sligo.

The scientific Bode* entertained the opinion, that the planetary distances, above Mercury, formed a geometrical series, each exterior orbit being double the distance of its next interior one, from the sun; a fact which obtains with remarkable exactness between Jupiter, Saturn, and Herschel. But this law seemed to be interrupted between Mars and Jupiter. Hence he inferred, that there was a planet wanting in that interval; which is now happily supplied by the discovery of the four *star-form* planets, occupying the very space where the unexplained vacancy presented a strong objection to his theory.

These bodies are *much smaller* in size than the older planets—they all revolve *at nearly the same distances* from the sun, and perform their revolutions in *nearly the same periods*,—their orbits are much *more eccentric*, and have a *much greater inclination* to the ecliptic,—and what is altogether singular, except in the case of comets—nearly *all cross each other*; so that there is even a *possibility* that two of these bodies may, some time, in the course of their revolutions, come into collision.

The orbit of Vesta is so eccentric, that she is sometimes farther from the sun than either Ceres, Pallas, or Juno, although her mean distance is many millions of miles less than theirs. The orbit of Vesta crosses the orbits of all the other three, in two opposite points.

From these and other circumstances, many eminent astronomers are of opinion, that these four planets are the fragments of a large celestial body which once revolved between Mars and Jupiter, and which burst asunder by some tremendous convul-

* According to him, the distances of the planets may be expressed nearly as follows: the earth's distance from the sun being 10.

Mercury,	$4 = 4$	Asteroids	$4+3\times2^{3} = 28$
Venus,	$4+3\times 1 = 7$	Jupiter,	$4+3\times2^{1} = 52$
The Earth,	$4+3\times 2 = 10$	Saturn,	$4+3\times2^{5} = 100$
Mars,	$4+3\times2^{2} = 16$	Herschel,	$4+3\times2^{6} = 196$

Comparing these values with the actual mean distances of the planets from the sun, we cannot but remark the near agreement, and can scarcely hesitate to pronounce that the respective distances of the planets from the sun, were assigned according to a law, although we are entirely ignorant of the exact law, and of the reason for that law.—*Brinkley's Elements*, p. 89.

sion, or some external violence. The discovery of Ceres by Piazzi, on the first day of the present century, drew the attention of all the astronomers of the age to that region of the sky, and every inch of it was minutely explored. The consequence was, that, in the year following, Dr. Olbers, of Bremen, announced to the world the discovery of Pallas, situated not many degrees from Ceres, and very much resembling it in size.

From this discovery, Dr. Olbers first conceived the idea that these bodies might be the fragments of a former world; and if so, that other portions of it might be found either in the same neighborhood, or else, having diverged from the same point, "they ought to have two common points of reunion, or two nodes in opposite regions of the heavens through which all the planetary fragments must sooner or later pass."

One of these nodes he found to be, in the constellation Virgo, and the opposite one, in the Whale; and it is a remarkable coincidence that it was in the neighborhood of the latter constellation that Mr. Harding discovered the planet Juno. In order, therefore, to detect the remaining fragments, if any existed, Dr. Olbers examined, three times every year, all the small stars in Virgo, and the Whale; and it was actually in the constellation Virgo, that he discovered the planet Vesta. Some astronomers think it not unlikely that other fragments of a similar description may hereafter be discovered. Dr. Brewster attributes the fall of meteoric stones to the smaller fragments of these bodies happening to come within the sphere of the earth's attraction.

Meteoric stones, or what are generally termed *aerolites*, are stones which sometimes fall from the upper regions of the atmosphere, upon the earth. The substance of which they are composed, is, for the most part, *metallic;* but the ore of which it consists is not to be found *in the same constituent proportions* in any known substance upon the earth. Their fall is generally preceded by a luminous appearance, a hissing noise, and a loud explosion; and, when found immediately after their descent, they are always hot, and usually covered with a black crust, indicating a state of exterior fusion.

Their size varies from that of small fragments of inconsiderable weight, to that of the most ponderous masses. They have been found to weigh from 300 pounds to several tons; and they have descended to the earth with a force sufficient to bury them many feet under the surface.

Some have supposed that they are projected from volcanoes in the moon; others, that they proceed from volcanoes on the earth; while others imagine that they are generated in the regions of the atmosphere; but the truth, probably, is not yet ascertained. In some instances, these stones have penetrated through the roofs of houses, and proved destructive to the inhabitants.

If we carefully compute the force of gravity in the moon, we shall find, that if a body were projected from her surface with a momentum that would cause it to move at the rate of 8,200 feet in the first second of time, and in the direction of a line joining the centers of the earth and moon, it would not fall again to the surface of the moon; but would become a satellite to the earth. Such an impulse might, indeed, cause it, even after many revolutions, to fall to the earth. The fall, therefore, of these stones, from the air, may be accounted for in this manner.

Mr. Harte calculates, that even a velocity of 6000 feet in a second, would be sufficient to carry a body projected from the surface of the moon beyond the power of her attraction. If so, a projectile force three times greater than that of a cannon, would carry a body from the moon beyond the point of equal attraction, and cause it to reach the earth. A force equal to this is often exerted by our volcanoes, and by subterranean steam. Hence, there is no impossibility in the supposition of their coming from the moon; but yet I think the theory of aerial consolidation the more plausible.

Of the old asteroids we present the following notices:

Vesta appears like a star of the 5th or 6th magnitude, shining with a pure steady radiance, and is the only one of the asteroids which can be discerned by the naked eye.

Juno, the next planet in order after Vesta, revolves around the sun in four years, four and a half months, at the mean distance of two hundred and fifty-four millions of miles, moving in her orbit at the rate of forty-one thousand miles an hour. Her diameter is estimated at 1393 miles. This would make her magnitude a hundred and eighty-three times less than the earth's. The light and heat which she receives from the sun is seven times less than that received by the earth.

The eccentricity of her orbit is so great, that her greatest distance from the sun is nearly double her least distance; so that, when she is in her *perihelion*, she is nearer the sun by a hundred and thirty millions of miles, than when she is in her *aphelion*. This great eccentricity has a corresponding effect upon her rate of motion; for being so much nearer, and therefore so much more powerfully attracted by the sun at one time than at another, she moves through that half of her orbit which is nearest the sun, in one half of the time that she occupies in completing the other half.

According to Schroeter, the diameter of Juno is 1425 miles; and she is surrounded by an atmosphere more dense than that of any of the other planets. Schroeter also remarks, that the variation in her brilliancy is chiefly owing to certain changes in the density of her atmosphere; at the same time he thinks it not improbable that these changes may arise from a diurnal revolution on her axis.

Ceres, the planet next in order after Juno, revolves about the sun in four years, seven and a third months, at the mean distance of two hundred and sixty-three and a half millions of miles, moving in her orbit at the rate of forty-one thousand miles an hour. Her diameter is estimated at 1582 miles, which makes her magnitude a hundred and twenty-five times less than the earth's. The intensity of the light and heat which she receives from the sun, is about seven and a half times less than that of those received by the earth.

Ceres shines with a ruddy color, and appears to be only about the size of a star of the eighth magnitude. Consequently she is never seen by the naked eye. She is surrounded by a species of cloudy or nebulous light, which gives her somewhat the appearance of a comet, forming, according to Schroeter, an atmosphere six hundred and seventy-five miles in hight.

Ceres, as has been said, was the first discovered of the asteroids. At her discovery, astronomers congratulated themselves upon the harmony of the system being restored. They had long wanted a planet to fill up the great void between Mars and Jupiter, in order to make the system complete in their own eyes; but the successive discoveries of Pallas and Juno again introduced confusion, and presented a difficulty which they were unable to solve, till Dr. Olbers suggested the idea that these small anomalous bodies were merely the fragments of a larger planet, which had been exploded by some mighty convulsion. Among the most able and decided advocates of this hypothesis, is Dr. Brewster, of Edinburgh.

Pallas, the next planet in order after Ceres, performs her revolution around the sun in four years, seven and two-third months, at the mean distance of two hundred and sixty-four millions of miles, moving in her orbit at the rate of forty-one thousand miles an hour. Her diameter is estimated at 2025 miles, which is but little less than that of our moon. It is a singular and very remarkable phenomenon in the solar system, that two planets, (Ceres and Pallas,) nearly of the same size, should be situated at equal distances from the sun, revolve about him in the same period, and in orbits that intersect each other. The difference in the respective distances of Ceres and Pallas is less than a million of miles. The difference in their sidereal revolutions, according to some astronomers, is but a single day!

The calculation of the latitude and longitude of the asteroids, is a labor of extreme difficulty, requiring more than four hundred equations to reduce their anomalous perturbations to the true place. This arises from the want of auxiliary tables, and from the fact that the elements of the star-form planets, are very imperfectly determined. Whether any of the asteroids has a rotation on its axis, remains to be ascertained. The following table exhibits the present state of knowledge with reference to the asteroids. The longitudes are referred to the mean equinox, Jan. 1, 1848, except Metis, which is for April 30, 1848.

The following tables present a synopsis of the present knowledge of the asteriods.

Names.	Rev. in Sid. days.	Aph. Dist.	Peri. Dist.
1 Flora,	1193.25	2.547126	1.856244
2 Vesta,	1325.22	2.571997	2.150345
3 Iris,	1345.16	2.935335	1.834262
4 Metis,	1346.40		
5 Hebe,	1375.25	2.903557	1.936886
6 Astrea,	1510.75	3.060943	2.092456
7 Juno,	1594.68	3.349363	1.993166
8 Ceres,	1680.96	2.979793	2.553746
9 Pallas,	1685.55	3.438312	2.105304

ELEMENTS.

Names.	Epoch.	Mean anomaly.	Long. asc. node.
1 Flora,	1848 Jan. 1.0	35° 53′ 32″.0	110° 18′ 50″.8
2 Vesta,	1847 April, 4.0	310 46 14 .7	103 22 01 .3
3 Iris,	1847 Sept. 1.0	298 16 37 .2	259 45 19 .6
4 Metis,	1848 April, 30.0	141 54 11 .82	68 29 40 .4
5 Hebe,	1847 July, 10.0	274 54 02 .6	138 40 44 .8
6 Astrea,	1847 March, 16.0	63 30 49 .3	141 29 29 .2
7 Juno,	1847 July, 9.5	258 06 02 .1	170 53 52 .0
8 Ceres,	1848 March, 12.0	21 04 00 .5	80 47 17 .9
9 Pallas,	1848 March, 4.0	24 57 23 .4	172 42 12 .3

ELEMENTS,—*Continued.*

Names.	Long asc. node.—Long. of Perihelion.	Inclination.	Ang. of Eccentricity.
1 Flora,	77° 26′ 49″.1	5° 52′ 55″.9	9° 01′ 36″.9
2 Vesta,	212 16 14 .4	7 08 30 .3	5 07 21 .5
3 Iris,	218 18 35 .6	5 28 10 .9	13 20 50 .1
4 Metis,	4 20 27 .7	5 35 24 .0	7 13 36 .9
5 Hebe,	123 36 42 .1	14 44 25 .3	11 31 11 .4
6 Astrea,	6 00 31 .4	5 19 17 .1	10 49 55 .6
7 Juno,	116 35 04 .0	13 02 39 .3	14 42 19 .6
8 Ceres,	293 28 14 .7	10 37 13 .1	4 24 56 .8
9 Pallas,	51 26 35 .1	34 37 31 .1	13 54 48 .9

Names.	Mean daily Sid. mo.
1 Flora, - -	1086″.1100
2 Vesta, - -	977 .948
3 Iris, - -	963 .4498
4 Metis, - -	962 .5660
5 Hebe, - -	942 .3754
6 Astrea, - -	857 .8493
7 Juno, - -	812 .7012
8 Ceres, - -	770 .9866
9 Pallas, - -	768 .8858

From these elements and data, some curious results may be obtained with reference to the orbits of eight of the asteroids. The last discovered, Metis, is not yet sufficiently known to include it in these examinations.

There are ten cases where the orbits are entirely enclosed the one within the other, viz.

Flora in Hebe.
Iris and Flora in Juno.
Astrea and Vesta in Pallas.
Iris, Flora, Pallas, Astrea and Vesta in Ceres.

The following orbits interlock like the links of a chain, viz.

Hebe and Astrea.	Hebe and Iris.	Ceres and Juno.
Juno and Astrea.	Vesta and Iris.	Pallas and Hebe.
Vesta and Astrea.	Flora and Iris.	Vesta and Hebe.
Flora and Astrea.	Pallas and Juno.	Ceres and Hebe.
Iris and Astrea.	Vesta and Juno.	Pallas in Flora.
Pallas in Iris.	Hebe and Juno.	Vesta in Flora.

In those cases where the orbits interlock with each other, as the nodes of one orbit on any other are perpetually shifting, the time may come when an actual intersection of the orbits may take place. If at such a time the two planets should be found at the same time in this now common point of their orbits, a collision would take place, which, in consequence of the probable rotary motion of the moving bodies, would produce a sudden and terrific shock. The very near equality of the orbital motions would secure the planets from any severe collision from their velocities in their orbits.

If the knowledge of these minute planets was perfect, it would not be impossible to compute backward or forward and ascertain the time when the orbits of any pair actually intersected each other, and where the planets were at the time of this intersection. Could the intervals between the times of intersection be obtained, combining these with the periods of the asteroids in their orbits, it would become possible to compute the time when a collision of the planets is to take place.

By computations Encke found that about the year A. D. 3397, the orbit of Ceres would actually cut the orbit of Pallas; but to obtain the positions of the planets in their orbits, at the time of intersection, has not been attempted.

The hypothesis of Olbers gathers strength from every new asteroid discovered, although the fact that the aphelion of Flora is shorter than the perihelion of Ceres, presents a difficulty which had not before existed.

JUPITER.

Jupiter is the largest of all the planets belonging to the solar system. It may be readily distinguished from the fixed stars, by its peculiar splendor and magnitude; appearing to the naked eye almost as resplendent as Venus, although it is more than seven times her distance from the sun.

When his right ascension is less than that of the sun, he is our morning star, and appears in the eastern hemisphere before the sun rises; when greater, he is our evening star, and lingers in the western hemisphere after the sun sets.

Nothing can be easier than to trace Jupiter among the constellations of the zodiac; for in whatever constellation he is seen to-day, one year hence he will be seen equally advanced in the *next* constellation; two years hence, in the next; three years hence, in the next, and so on; being just a year, at a mean rate, in passing over one constellation.

The exact mean motion of Jupiter in its orbit, is about one twelfth of a degree in a day; which amounts to only 30° 20′ 32″ in a year.

Jupiter is the next planet in the solar system above the asteroids, and performs his annual revolution around the sun in nearly 12 of our years, at the mean distance of 495 millions of miles; moving in his orbit at the rate of 30,000 miles an hour.

The exact period of Jupiter's sidereal revolution is 11 years, 10 months, 17 days, 14 hours, 21 minutes, 25½ seconds. His exact mean distance from the sun is 495,533,837 miles; consequently, the exact rate of his motion in his orbit, is 29,943 miles per hour.

He revolves on an axis, which is perpendicular to the plane of his orbit, in 9 hours, 55 minutes, and 50 seconds; so that his year contains 10,471 days and nights; each about 5 hours long.

His form is that of an oblate spheroid, whose polar diameter is to its equatorial, as 13 to 14. He is therefore considerably more flattened at the poles, than any of the other planets, except Saturn. This is caused by his rapid rotation on his axis; for it is a universal law, that the equatorial parts of every body revolving on an axis, will be swollen out in proportion to the density of the body, and the rapidity of its motion.

The difference between the polar and equatorial diameters of Jupiter, exceeds 6000 miles. The difference between the polar and equatorial diameters of the earth, is only 26 miles. Jupiter, even on the most careless view through a good telescope, appears to be oval; the longer diameter being parallel to the direction of his belts, which are also parallel to the ecliptic.

By this rapid whirl on his axis, his equatorial inhabitants are carried around at the rate of 26,554 miles an hour; which is 1600 miles farther than the equatorial inhabitants of the earth are carried, by its diurnal motion, in *twenty-four hours*.

The true *mean* diameter of Jupiter is 86,255 miles; which is nearly 11 times greater than the earth's. His volume is, therefore, about *thirteen hundred* miles larger than that of the earth. On account of his great distance from the sun, the degree of light and heat which he receives from it, is 27 times *less* than that received by the earth.

When Jupiter is in conjunction, he rises, sets, and comes to the meridian with the sun; but is never observed to make a transit, or pass over the sun's disk; when in opposition, he rises when the sun sets, sets when the sun rises, and comes to the meridian at midnight, which never happens in the case of an *interior* planet. This proves that Jupiter revolves in an orbit which is *exterior* to that of the earth.

As the variety in the seasons of a planet, and in the length of its days and nights, depends upon the inclination of its axis to the plane of its orbit, and as the axis of Jupiter has no inclination, there can be no difference in his seasons, on the same parallels of latitude, nor any variation in the length of his days and nights. It is not to be understood, however, that *one uniform season* prevails from his equator to his poles; but that the *same parallels of latitude* on each side of his equator, uniformly enjoy the same season, whatever season it may be.

About his equatorial regions, there is perpetual summer; and at his poles, everlasting winter; but yet equal day and equal night at each. This arrangement seems to have been kindly ordered by the beneficent Creator; for had his axis been inclined to his orbit, like that of the earth, his polar winters would have been alternately a dreadful night of *six years darkness*.

Jupiter, when viewed through a telescope, appears to be surrounded by a number of luminous zones, usually termed *belts*, that frequently extend quite around him. These belts are parallel not only to each other, but, in general, to his equator, which is also nearly parallel to the ecliptic. They are subject, however, to considerable variation, both in breadth and number. Sometimes eight have been seen at once; sometimes only one, but more usually three. Dr. Herschel once perceived his whole disk covered with small belts.

Sometimes these belts continue for months at a time with little or no variation, and sometimes a new belt has been seen to form in a few hours. Sometimes they are interrupted in their length; and at other times, they appear to spread in width, and run into each other, until their breadth exceeds 5,000 miles.

Bright and dark spots are also frequently to be seen in the belts, which usually disappear with the belts themselves, though not always, for Cassini observed that one occupied the same position more than 40 years. Of the *cause* of these variable appearances, but little is known. They are generally supposed to be nothing more than *atmospherical phenomena*, resulting from, or combined with, the rapid motion of the planet upon its axis.

Different opinions have been entertained by astronomers respecting the cause of these belts and spots. By some they have been regarded as clouds, or as openings in the atmosphere of the planet, while others imagine that they are of a more permanent nature, and are the marks of great physical revolutions, which are perpetually agitating and changing the surface of the planet. The first of these opinions sufficiently explains the variations in the form and magnitude of the *spots*, and the *parallelism* of the belts. The spot first observed by Cassini, in 1665, which has both disappeared and reappeared in the same form and position for the space of 43 years, could not possibly be occasioned by any atmospherical variations, but seems evidently to be connected with the surface of the planet. The form of the belt, according to some astronomers, may be accounted for by supposing that the *atmosphere* reflects more light than the *body* of the planet, and that the clouds which float in it, being thrown into parallel strata by the rapidity of its diurnal motion, form regular *interstices*, through which are seen its opake body, or any of the permanent spots which may come within the range of the opening.

Jupiter is also attended by four satellites or moons, some of which are visible to him every hour of the night; exhibiting, on a small scale and in short periods, most of the phenomena of the solar system. When viewed through a telescope, these satellites present a most interesting and beautiful appearance. The first satellite, or that nearest the planet, is 259,000 miles distant from its center, and revolves around it in 42½ hours; and appears, at the surface of Jupiter, four times larger than our moon does to us. His second satellite, being both smaller and farther distant, appears about the size of ours; the third, somewhat less; and the fourth, which is more than a million of miles from him, and takes 16¾ days to revolve around him, appears only about *one third* the diameter of our moon.

These satellites suffer frequent eclipses from passing through Jupiter's shadow; in the same manner as our moon is eclipsed in passing through the earth's shadow. The three nearest satellites fall into his shadow, and are eclipsed, in every revolution; but the orbit of the fourth is so much inclined, that it passes by its opposition to him, two years in six, without falling into his shadow. By means of these eclipses, astronomers have not only discovered that light is 8 minutes and 13 seconds in coming to us from the sun, but are also enabled to determine the longitude of places on the earth with greater facility and exactness than by any other methods yet known.

It was long since found, by the most careful observations, that when the earth is in that part of her orbit which is nearest to Jupiter, the eclipses appear to happen 8′ 13″ *sooner* than the tables predict; and when in that part of her orbit which is farthest from him, 8′ 13″ *later* than the tables predict; making a total difference in time, of 16′ 26″. From the mean of 6000 eclipses observed by Delambre, this disagreement between *observation* and *calculation*, was satisfactorily settled at 8′ 13″, while both were considered equally correct. Now, when the eclipses happen *sooner* than the tables, Jupiter is at his nearest approach to the earth—when *later*, at his greatest distance; so that the difference in his distances from the earth, in the two cases, is the *whole diameter of the earth's orbit*, or about 190 millions of miles. Hence, it is concluded that light *is not instantaneous*, but that it occupies 16′ 26″ in passing across the earth's orbit, or 8′ 13″ in coming from the sun to the earth; being nearly 12 millions of miles a minute.

The revolutions of the satellites about Jupiter are precisely similar to the revolutions of the planets about the sun. In this respect they are an epitome of the solar system, exhibiting, on a smaller scale, the various changes that take place among the planetary worlds.

Jupiter, when seen from his nearest satellite, appears a *thousand times larger* than our moon does to us, exhibiting on a scale of inconceivable magnificence, the varying forms of a crescent, a half moon, a gibbous phase, and a full moon, every forty-two hours.

Elements of Jupiter and his satellites for Jan 1st, 1801.

PLANET.

Mean sid. revolu. (nearly 12 years), solar days,	4332d. 14h. 02m. 08.5s.
Mean synodic rev. solar days, - -	398.867
Mean longitude, - -	112° 15′ 23″.0
Mean orbital mo. in a solar day, - -	4 59 .26
Do. per annum, - -	30 20 32 .0
Longitude of perihelion, - -	11 08 34 .6
Annual mo. of apsides eastward, - -	6 .96
Do. referred to the ecliptic, - -	57 .06
Inclination of orbit to the ecliptic, -	1 18 51 .3
Annual decrease of do. -	0 .226
Longitude of ascending node - -	98 26 18 .9
Motion of do. west per annum, - -	15 .8
Ditto east, referred to the ecliptic, - -	34 .3
Eccentricity of orbit, half maj. axis unity, -	0.0481621
Increase of ditto in a century, -	0.000159350
Greatest equation of center, -	5° 31′ 13″.8
Annual increase of ditto, - -	0 .634
Rotation on axis, -	9h. 55m. 49.7s.
Inclination of axis to ecliptic, - -	3° 05′ 30″.0
Mean apparent eq. diam. - -	36 .74
Ditto at conjunction, - - - - -	30 .00
Ditto at opposition - - - - -	45 .88
True diam. (90,000 miles nearly) earth's diam. unity, -	10 .860
Volume, earth's as unity, - - -	1280.9
Mass, sun's as unity, - - - - -	0.0009341431
Density, sun's as unity, - - - - -	0.99239
Mean distance (485,000,000 miles), earth's as unity, -	5.202776

ELEMENTS.	SATELLITES.			
	First.	Second.	Third.	Fourth.
Sid. rev. in m. solar days,	1d. 18h. 28m.	3d. 13h. 14m.	7d. 3h. 43m.	16d. 16h. 32m.
Ditto for computation,	1 .7691378	3 .5518101	7 .1545528	16 6887697
Mean app. diam.	1″.015	0″.911	1″.488	1″.273
Ditto in miles,	2508	2068	3377	2890
Mass, Jup. as one.	0.0000173	0.0000232	0.0000885	0.0000427
M. dist. Jup. eq. rad. as 1.	6.04853	9.62347	15 35024	26.99835
Ditto in degrees,	0° 1′ 57″.92	0° 3′ 07″.64	0° 04′ 59″.32	0° 8′ 46″.48
Ditto in miles,	260,000	420,000	670,000	1.180.000

A most curious phenomenon with reference to one of the satellites of Jupiter, has recently been observed at the Cambridge observatory, and also at the Cincinnati observatory. In passing across the disk of the planet, it has been seen to lose its light as if undergoing eclipse, until it finally becomes a *black* spot on the disk of the planet; after passing off the disk it resumes its light.

SATURN.

SATURN is situated between the orbits of Jupiter and Herschel, and is the most remote planet from the earth of any that are visible to the naked eye. It may be easily distinguished from the fixed stars by its pale, feeble, and steady light. It resembles the star Fomalhaut, both in color and size, differing from it only in the steadiness and uniformity of its light.

From the slowness of its motion in its orbit, the pupil, throughout the period of his whole life, may trace its apparent course among the stars, without any danger of mistake. Having once found when it enters a particular constellation, he may easily remember where he is to look for it in any subsequent year; because, at a mean rate, it is just two and a half years in passing over a single sign or constellation.

Saturn's mean daily motion among the stars is only about 2′, the *thirtieth part of a degree.*

Saturn entered the constellation Virgo about the beginning of 1833, and continued in it until the middle of the year 1835, when he passed into Libra. He will continue in that constellation until 1838; and so on; occupying about 2½ years in each constellation, or nearly thirty years in one revolution.

The mean distance of Saturn from the sun is nearly double that of Jupiter, being about nine hundred and nine millions of miles. His diameter is about 82,000 miles; his volume therefore is *eleven hundred times* greater than the earth's. Moving in his orbit at the rate of 22,000 miles an hour, he requires twenty-nine and a half years to complete his circuit around the sun:

but his diurnal rotation on his axis is accomplished in ten and a half hours. His year, therefore, is nearly thirty times as long as ours, while his day is shorter by more than one half. His year contains about 25,150 of its own days, which are equal to 10,759 of our days.

The surface of Saturn, like that of Jupiter, is diversified with belts and dark spots. Dr. Herschel sometimes perceived five belts on his surface; three of which were dark, and two bright. The dark belts have a yellowish tinge, and generally cover a broader zone of the planet than those of Jupiter.

To the inhabitants of Saturn, the sun appears ninety times less than he appears to the earth; and they receive from him only *one ninetieth part* as much light and heat. But it is computed that even the *ninetieth part* of the sun's light exceeds the illuminating power of 3,000 full moons, which would be abundantly sufficient for all the purposes of life.

The telescopic appearance of Saturn is unparalleled. It is even more interesting than Jupiter, with all his moons and belts. That which eminently distinguishes this planet from every other in the system, is a magnificent zone or ring, encircling it with perpetual light.

The light of the ring is more brilliant than the planet itself. It turns around its center of motion in the same time that Saturn turns on its axis. When viewed with a good telescope, it is found to consist of two concentric rings, divided by a dark band.

By the laws of mechanics, it is impossible that the body of the rings should retain its position by the adhesion of the particles alone; it must necessarily revolve with a velocity that will generate centrifugal force sufficient to balance the attraction of Saturn. Observation confirms the truth of these principles, showing that the rings rotate about the planet in $10\frac{1}{3}$ hours, which is considerably less than the time a satellite would take to revolve about it at the same distance. Their plane is inclined to the ecliptic in an angle of 31°. In consequence of this obliquity of position, they always appear elliptical to us, but with an eccentricity so variable as to appear, occasionally, like a straight line drawn across the planet; in which case they are visible only by the aid of superior instruments. Such was their position in April, 1833; for the sun was then passing from their south to their north side. The rings intersect the ecliptic in two opposite points, which may be called their nodes. These points are in longitude 170°, and 350°. When, therefore, Saturn is in either of these points, his rings will be invisible to us. On the contrary, when his longitude is 80°, or 200°, the rings may be seen to the greatest advantage. As the edges of the rings will present themselves to the sun twice in each revolution of the planet, it is obvious that the disappearance of them will occur once in about 15 years; subject, however, to the variation dependent on the position of the earth at that time.

The following are the dates during the ensuing revolutions of the planet, when its mean *heliocentric* longitude is such that the rings will (if the earth be favorably situated), either be invisible, or seen to the greatest advantage.

1838 July,	20° of Scorpio,	North side illuminated.
1847 Dec.	20° of Aquarius,	Invisible.
1855 April,	20° of Gemini,	South side illuminated.
1863 Nov.	20° of Virgo,	Invisible.

The distance between Saturn and his inner ring, is only 21,000 miles; being less than a *tenth part* of the distance of our moon from the earth. The breadth of the dark band, or the interval between the rings, is hardly 3,000 miles.—The breadth of the inner ring, is 20,000 miles. Being only about the same distance from Saturn, it will present to his inhabitants a luminous zone, arching the whole concave vault from one hemisphere to the other with a broad girdle of light.

The most obvious use of this double ring is, to reflect light upon the planet in the absence of the sun; what other purposes it may be intended to subserve, is to us unknown. The sun, as has been shown, illuminates one side of it during 15 years, or one half of the period of the planet's revolution; and during the next 15 years, the other side is enlightened in its turn.

Twice in the course of 30 years, there is a short interval of time when neither side is enlightened, and when, of course, it ceases to be visible;—namely, at the time when the sun ceases to shine on one side, and is about to shine on the other.* It revolves around its axis, and consequently, around Saturn, in 10½° hours, which is at the rate of a thousand miles a minute, or 58 times swifter than the revolution of the earth's equator.

When viewed from the middle zone of the planet, in the absence of the sun, the rings will appear like vast luminous arches, extending along the canopy of heaven, from the eastern to the western horizon, exceeding in breadth a hundred times the apparent diameter of our moon.

Besides the rings, Saturn is attended by seven satellites, which revolve about him at different periods and distances, and reciprocally reflect the sun's rays on each other and on the planet. The rings and moons illuminate the nights of Saturn; the moons and Saturn enlighten the rings, and the planet and rings reflect the sun's beams on the satellites.

The *fourth* of these satellites (in the order of their distance) was *first* discovered by Huygens, on the 25th of March, 1655, and, in honor of

* This happens, as we have already shown, when Saturn is either in the 20th degree of Pisces, or the 20th degree of Virgo. When he is between these points, or in the 20th degree either of Gemini or of Sagittarius, his ring appears most open to us, and more in the form of an oval, whose longest diameter is to the shortest as 9 to 4.

the discoverer, was called the *Huygenian Satellite.* This satellite, being the largest of all, is seen without much difficulty. Cassini discovered the 1st, 2d, 3d, and 5th satellites, between October, 1671, and March, 1684. Dr. Herschel discovered the 6th and 7th in 1789. These are nearer to Saturn than any of the rest, though, o avoid confusion, they are named in the order of their discovery.

The sixth and seventh are the smallest of the whole; the first and second are the next smallest; the third is greater than the first and second; the fourth is the largest of them all; and the fifth surpasses the rest in brightness.

Their respective distances from their primary, vary from half the distance of our moon, to two millions of miles. Their periodic revolutions vary from 1 day to 79 days. The orbits of the six inner satellites, that is, the 1st, 2d, 3d, 4th, 6th, and 7th, all lie in the plane of Saturn's rings, and revolve around their outer edge; while the 5th satellite deviates so far from the plane of the rings, as sometimes to be seen *through the opening* between them and the planet.

Laplace imagines that the accumulation of matter at Saturn's equator retains the orbits of the first six satellites in the plane of the equator, in the same manner as it retains the rings in that plane. It has been satisfactorily ascertained, that Saturn has a greater accumulation of matter about his equator, and consequently that he is more flattened at the poles, than Jupiter, though the velocity of the equatorial parts of the former is much less than that of the latter. This is sufficiently accounted for by the fact, that the *rings* of Saturn lie in the plane of his equator, and act more powerfully upon those parts of his surface than upon any other; and thus, while they aid in diminishing the gravity of these parts, also aid the centrifugal force in flattening the poles of the planet. Indeed, had Saturn never revolved upon his axis, the action of the rings would, of itself, have been sufficient to give him the form of an oblate spheroid.

Saturnian elements, January 1, 1801:

Mean distance (about 890,000,000 miles), earth's as one,	9.538786
Mean sid. rev. (29,456 years), mean solar days, -	10759.2198
Mean synod. rev. in mean solar days, - -	378.090
Mean longitude, - - - - - -	135° 20′ 06″.5
Mean orbital motion in a mean solar day, - -	2′ 00″.6
Do. in a solar year, - - - - -	12° 13′ 36″.1
Longitude of perihelion, - - - -	89° 09′ 29″.8
Ann. mo. of apsides eastward, - - - -	19″.4
Ditto referred to ecliptic, - - - -	1′ 09″.5
Inclination of orbit to ecliptic, - - - -	2° 29′ 35″.7
Annual decrease of ditto, - - - - -	0″.155
Long. of ascend. node, - - - - -	111° 56′ 37″.40
Motion of do. per an. west, - - - -	19″.4
" " " " " east, ref. to ecliptic, -	30″.7
Eccentricity half maj. axis unity, - - -	0.0561505

Decrease of do. in a century,	0.000312402
Greatest equation of center,	6° 26′ 12″.00
Annual decrease of do.	1″.279
Rotation on axis,	10 h. 29 m. 16.8 s.
Inclination of axis to ecliptic,	31° 19′
App. diam. at mean dist. from the earth,	16″.20
True diam. (about 76068 miles), earth's as unity,	9.982
Volume, earth's as unity,	995.00
Mass, sun's as unity,	0.0002847380
Density, sun's as unity,	0.550

THE RINGS.

		Miles.
Outer diam. of exterior ring,	40″.095	176.418
Inner " " " "	35 .289	155.272
Outer diam. of inner ring,	34 .475	151.690
Inner " " " "	26 .668	117.339
Equat. diam. of planet,	17 .991	79.160
Breadth of division between the rings,	0 .408	1.791
Dist. of ring from the planet,	4 .339	19.090

The multiple division of Saturn's rings has been a matter of some dispute. There now seems little doubt that the exterior ring is divided into two rings. Prof. Encke saw the division distinctly, April 25, 1837. On the 25th of May he obtained these approximate measures:

Outer diam. of ext. ring,	40″.455
" " " new division,	37 .471
Inner diam. of outer ring,	36 .038
Outer diam. of inner ring,	34 .749
Inner diam. of inner ring,	26 .756

These are the only measures which I have seen. The third division was distinctly observed on the 7th September, 1843, at Mr. Lassell's observatory, near Liverpool. Since the erection of the Refractor of the Cincinnati Observatory, the planes of Saturn's rings have been too much inclined to the visual ray for exact examination. I have never been able to make out the triple division of the rings.

It has been found that the laws of perfect equilibrium require that the center of the rings should not coincide with the center of the planet. Exact measures have shown that this discovery of theory is verified in nature. There is a slight difference in the respective distances from the planet to the inner edge of the ring on the right and left, amounting to about two-tenths of a second of arc.

Saturn is one of the most magnificent objects in the heavens, when seen with a powerful telescope, and never fails to excite the most profound admiration in the beholder.

The satellites of Saturn are by no means as well known as those of Jupiter. The two inner satellites are among the most difficult objects to be seen in the heavens. The following elements may be regarded as a near approximation to the truth.

Satellite.		Sidereal Revolution in mean Solar Day.	Mean Distance.			Discoverer and Date.
Order from Planet.	Old Order.		Saturn's Radius as unity.	Angle subtended.	Miles.	
		d. h. m.		′ ″		
I	7	0 22 38	3.351	29.15	120,000	W. Herschel, 1789
II	6	1 08 53	4.300	31.19	150,000	" " "
III	1	1 21 18	5.284	45.13	190,000	D. Cassini, . 1684
IV	2	2 17 45	6.819	1 00.93	243,000	" " "
V	3	4 12 25	9.524	1 24.86	340,000	" " "
VI	4	15 22 41	22.081	3 26.50	788,000	C. Huygens, 1655
VII	5	79 07 55	64.359	9 28.00	2,297,000	D. Cassini, . 1671

URANUS OR HERSCHEL.

Uranus is the planet next beyond Saturn; to the naked eye, it appears like a star of only the sixth or seventh magnitude, and of a pale, bluish white; but it can seldom be seen, except in a very fine, clear night, and in the absence of the moon.

As it moves over but one degree of its orbit in eighty-five days, it will be *seven years* in passing over one sign or constellation.

When first seen by Dr. Herschel, in 1781, it was in the foot of *Gemini; so that it has not yet completed one revolution since it was discovered to be a planet.*

It is remarkable that this body was observed as far back as 1690. It was seen three times by Flamstead, once by Bradley, once by Mayer, and eleven times by Lemonnier, who registered it among the stars; but not one of them suspected it to be a planet.

The inequalities in the motions of Jupiter and Saturn, which could not be accounted for from the mutual attractions of these planets, led astronomers to suppose that there existed another planet beyond the orbit of Saturn, by whose action these irregularities were produced. This conjecture was confirmed March 13th, 1781, when Dr. Herschel discovered the *motions* of this body, and thus proved it to be a planet.

Herschel is attended by six moons or satellites, which revolve about him in different periods, and at various distances. Four of them were discovered by Dr. Herschel, and two by his sister, Miss Caroline Herschel. It is possible that others remain yet to be discovered.

Uranus' mean distance from the sun is 1828,000,000 of miles; more than twice the mean distance of Saturn. His sidereal revolution is performed in 84 years and 1 month, and his motion in his orbit is 15,600 miles an hour. He is supposed to have a rotation on his axis, in common with the other planets; but astronomers have not yet been able to obtain any occular proof of such a motion.

His diameter is estimated at 34,000 miles; which would make his volume more than 80 times larger than the earth's. To his inhabitants, the sun appears only the $\frac{1}{368}$ part as large as he does to us; and of course they receive from him only that small proportion of light and heat. It may be shown, however, that the $\frac{1}{368}$ part of the sun's light exceeds the illuminating power of 800 full moons. This, added to the light they must receive from their six satellites, will render their days and nights far from cheerless.

But three of the six satellites reported by Herschel, have been observed by those who have followed him.

The following elements are for the epoch 1st January, 1801, reckoning from the mean equinox:

Mean sid. rev. (84.02 years), solar days, - -	30686.821 d.
" synod. rev. " " " " - -	369.656 "
Mean longitude, - - - -	177° 48′ 23″.0
Mean motion in orbit in a mean solar day, - -	42″.37
Do. per annum, - - - - -	4° 17′ 45″.16
Long. of perihelion, - - - -	167 31 16 .10
Annual mo. of apsides east, - - -	52 .50
Inclination of orbit, - - - -	0° 46′ 28 .44
Long. of ascending node, - - -	72 59 35 .30
Ann. mo. of do. eastward, - - -	14 .16
Eccentricity of orbit. Semi axis maj. unity, -	0.04667938
Greatest equation of center. - - -	5° 20′ 57″.00
Mean app. diam. (35,000 miles scarcely), -	4 .00
True diam., earth's as unity, - - - -	4.344
Mass, sun as unity, - - - - -	0.0000558098
Volume, earth as unity, - - - - - -	82
Density, sun's as unity, - - - - -	1.100
Mean distance (1,800,000,000 miles), earth's as unity,	19.182390

Herschel's Satellites.	Sidereal Revolution.				Mean Distance.—Semi-diameter = 1 of Planet.
	d.	h.	m.	s.	
I	5	21	25	20	13.120
II	8	16	57	47	17.022
III	10	23	02	47	19.845
IV	13	10	56	29	22.752
V	38	01	48	00	45.507
VI	107	16	39	56	91.008

Herschel's periods, of two of these satellites, have been confirmed by his son, and by Dr. Lamont, of Munich; a third one has recently been observed by Strüve of Pulkova.

From an extensive series of measures, a flattening at the poles, and a protuberance at the equator of this planet has been detected, demonstrating a rotation upon an axis, in accordance with the general analogy of the planets.

NEPTUNE (FIRST CALLED LEVERRIER).

THIS is the most remote and the latest discovered of all the large planets. The extraordinary circumstances attending its discovery, have given to this object an interest which does not attach to any other heavenly body. After the discovery of Uranus, in 1781, efforts were made to reduce its motions to the known laws of gravitation, and an orbit was computed, which, in the outset, it was thought would represent all the observed places of Uranus, and by which its future places might be predicted. In a short time this orbit was found to be at fault: the planet was gradually leaving it, and seemed to be under some unknown influence, which involved its motions in mystery.

After the lapse of many years from the discovery of Uranus, M. Bouvard resumed the investigation of its orbit, and finally reached the conclusion that it was impossible to represent at the same time, by any orbit, the old observed places of the planet and the new ones, or those taken after the star was discovered to be a planet. He, therefore, rejected the ancient observations as more likely to be in error, and adopting the recent ones, computed an orbit and tables for Uranus, which it was hoped might represent the future places of the planet.

A few years sufficed to show that this orbit and these tables were defective. The computed and the observed places of the planet did not agree, and the difference increased from year to year, until it attracted the attention of many distinguished astronomers. Some were disposed to attribute these irregularities to a relaxation of the rigorous laws of gravitation in those remote regions of space; others conceived that Uranus might be attended by some large satellite which was swaying it from its computed orbit: while another class conceived the possible existence of a remote undiscovered planet, under whose influence Uranus was made to break away from its computed track.

Under these circumstances, a young astronomer, M. Leverrier, of Paris, as early as 1845, at the request of M. Arago, undertook a thorough discussion of the irregularities of Uranus, with a view to understand their cause; and in case this cause should be an exterior planet, to determine, from the known irregularities of Uranus, the actual place of the unknown disturbing planet at a given epoch.

M. Leverrier commenced by determining, with all accuracy, the disturbing influence on Uranus, exerted by all the *known* bodies of the solar system, and more especially the effects of the large and nearer planets Saturn and Jupiter. His memoir on this subject was presented to the Academy of Sciences of Paris, on the 10th Nov., 1845. On the first of the following June, he read a second memoir before that learned body, in which he demonstrates that the irregularities of Uranus cannot be explained by any known causes; and concludes that they are due to an unknown planet revolving in an orbit exterior to that of Uranus, and as far from Uranus as it is from the sun; and whose place, as roughly determined, was, on the 1st January, 1847, in longitude 325°. On the 30th August, 1846, a third memoir was read, in which the author fixes the approximate elements of his theoretical planet, its mass, and its position for the 1st January, 1847, in heliocentric longitude 326° 32′. On the 5th October, 1846, a fourth and last memoir was presented to the Academy, in which M. Leverrier discusses the position of the plane of the orbit of his unknown planet.

These wonderful accounts excited the greatest interest among astronomers, yet such was the difficulty of the problem, that few were willing to believe that Leverrier's computation would ever lead to the discovery of his imaginary planet. These misgivings were soon dissipated. On the 1st of Sept., 1846, M. Leverrier wrote to his friend Dr. Galle, of Berlin, requesting him to direct his telescope to the place in the heavens which his calculations had indicated as the place of his planet at that date. This request was immediately complied with; and on the very first evening of examination, the planet was actually discovered within less than one degree of the place pointed out by M. Leverrier!

In the mean time, the publications of Leverrier had brought to light the fact, that Mr. Adams, a young geometer of Cambridge, Eng., had discussed the very same problem, and had reached results almost exactly coincident with those of Leverrier. Indeed, Mr. Adams had obtained his results some months previous to M. Leverrier, but having failed to publish them to the world, thus gave to his distinguished rival the priority and right of discovery. The wonderful coincidence of the results obtained by Leverrier and Adams, seemed to fix absolutely the fact of the discovery of the planet from calculation. The news of its discovery was soon spread throughout the world, and excited every where the deepest interest. The intelligence reached Cincinnati on the 28th Oct., 1846, and on the same evening the planet was readily detected by its *disk* with the great refractor. Its diameter was immediately measured.

The new planet was now followed with great interest at all the principal observatories in the world, with the view of discovering how nearly the computed elements before discovery would agree with those determined from actual observation after discovery. As the planet moved extremely slow, this would have required a long series of years, but for a most important discovery made by Mr. S. C. Walker, then at the Washington observatory. After computing an orbit of the new planet from the best data then in existence, he traced it backward for fifty or sixty years, in the hope of finding that its place had been fixed long since by some astronomer who had observed it, believing it to be a fixed star. His research was rewarded with a brilliant discovery. Two places of the planet were obtained from the catalogue of Lalande, as far back as 1795, which, combined with recent places, gave sufficient data to determine with comparative accuracy the elements of the orbit of the new planet. A difficulty here arose, from the fact that a great discrepancy existed between the periodic time of the planet and that computed by M. Leverrier. His computed period was about 217 years, while the periodic time of Neptune is about 164. This discrepancy has induced some astronomers to assert that the discovery of the planet, after all, was *accidental.* This Leverrier denies; and here, for the present, the matter rests.

Prof. Pierce of Cambridge, after an elaborate research, finds that all the irregularities of Uranus are most perfectly accounted for by the influence of the new planet; so that in case this result may be relied on, this great problem is now absolutely exhausted.

The following are the elements computed, before discovery, by M. Leverrier:

Periodic time, years,	217.387
Mean distance, earth as unity,	36.1539
Mean longitude, 1st Jan., 1847,	318° 47′ 4″
Longitude of perihelion,	284 45 8
Mean anomaly,	34 01 56
Equation of center,	7 44 49
Heliocentric longitude, 1st Jan., 1847,	326 32
Radius vector, earth's unity,	33 06

Mass, $\frac{1}{9322}$ of the sun's mass.

Adams' elements, computed before discovery:

Mean longitude, Oct. 6th, 1846,	323° 02′
Longitude of perihelion,	299 11
Eccentricity,	0.120615
Mass, sun's as unity,	0.00018000

The elements obtained since the discovery of the planet by Mr. Walker, and by using the place of the planet observed by Lalande, 1795, are as follows. These will be gradually improved as observations are multiplied.

Long. perihelion point, -	47° 12′ 56″.73	m. eq. 1st. Jan., 1848.
Long. ascending node, - -	130 05 11 .04	m. eq. 1st. Jan., 1848.
Inclination, - - - -	1 46 58 .97	
Eccentricity, - - - -	0.00871946	
Mean daily sid. moton, - -	21″.55448	
Long. at epoch, - - -	330° 44′ 41″.82	m. noon, Greenwich, 1st. Jan., 1848.

Mr. Lassell, of Liverpool, discovered a satellite to Neptune, on which a sufficient number of observations have been made to determine, with considerable accuracy, the mass of the planet. This has been computed by Prof. Pierce, of Cambridge, and is found to differ considerably from that obtained by Leverrier before the discovery. From observations on Lassell's satellite by Mr. Bond, of Cambridge, the mass of Neptune is determined to be $\frac{1}{19844}$ of the sun's mass.

With this mass Prof. Pierce accounts for all the irregularities of Uranus, and closes, at least for the present, the investigation.

COMETS.

Comets, whether viewed as ephemeral meteors, or as substantial bodies, forming a part of the solar system, are objects of no ordinary interest.

When, with uninstructed gaze, we look upwards to the clear sky of evening, and behold, among the multitudes of heavenly bodies, one, blazing with its long train of light, and rushing onward toward the center of our system, we insensibly shrink back as if in the presence of a supernatural being.

But when, with the eye of astronomy, we follow it through its perihelion, and trace it far off, beyond the utmost verge of the solar system, till it is lost in the infinity of space, not to return for centuries, we are deeply impressed with a sense of that power which could create and set in motion such bodies.

Comets are distinguished from the other heavenly bodies, by their appearance and motion. The appearance of the planets is globular, and their motion around the sun is nearly in the same plane, and from west to east; but the comets have a variety of forms, and their orbits are not confined to any particular part of the heavens; nor do they observe any one general direction.

The orbits of the planets approach nearly to circles, while those of the comets are very elongated elipses. A wire hoop, for example, will represent the orbit of a planet. If two opposite sides of the same hoop be extended, so that it shall be long and narrow, it will then represent the orbit of a comet. The sun is always in one of the foci of the comet's orbit.

There is, however, a practical difficulty of a peculiar nature which embarrasses the solution of the question as to the form of the cometary orbits. It so happens that the only part of the course of a comet which can ever be visible, is a portion throughout which the ellipse, the parabola and hyperbola, so closely resemble each other, that no observations can be obtained with sufficient accuracy to enable us to distinguish them. In fact, the observed path of any comet, while visible, may belong either to an ellipse, parabola, or hyperbola.

That part which is usually *brighter*, or more *opake* than the other portions of the comet, is called the *nucleus*. This is surrounded by an *envelop*, which has a cloudy, or *hairy* appearance. These two parts constitute the body, and, in many instances, the whole of the comet.

Most of them, however, are attended by a long train, called the *tail;* though some are without this appendage, and as seen by the naked eye, are not easily distinguished from the planets. Others, again, have no apparent nucleus, and seem to be only globular masses of vapor.

Nothing is known with certainty of the composition of these bodies. The envelop appears to be nothing more than vapor, becoming more luminous and transparent when approaching the sun. As the comets pass between us and the fixed stars, their envelops and tails are so thin, that stars of very small magnitudes may be seen through them. Some comets, having no nucleus, are transparent throughout their whole extent.

The nucleus of a comet sometimes appears opake, and it then resembles a planet. Astronomers, however, are not agreed upon this point. Some affirm that the nucleus is always transparent, and that comets are in fact nothing but a mass of vapor, or less condensed at the center. By others, it is maintained that the nucleus is sometimes solid and opake. It seems probable, however, that there are three classes of comets, viz.: 1st. Those which have no nucleus, being transparent throughout their whole extent; 2d. Those which have a transparent nucleus; and, 3d. Those having a nucleus which is solid and opake.

A comet, when at a distance from the sun, viewed through a good telescope, has the appearance of a dense vapor surrounding the nucleus, and sometimes flowing far into the regions of space. As it approaches the sun, its light becomes more brilliant, till it reaches its perihelion, when its light is more dazzling than that of any other celestial body, the sun excepted. In this part of its orbit are seen to the best advantage the phenomena of this wonderful body, which has, from remote antiquity, been the specter of alarm and terror.

The luminous train of a comet usually *follows it*, as it approaches the sun, and *goes before it*, when the comet recedes from the sun; sometimes the tail is considerably curved towards the region to which the comet is tending, and in some instances it has been observed to form a right angle with a line drawn from the sun through the center of the comet. The tail of the comet of 1744, formed nearly a quarter of a circle; that of 1689, was curved like a Turkish sabre. Sometimes the same comet has several tails. That of 1744 had, at one time, no less than *six*, which appeared and disappeared in a few days. The comet of 1823 had, for several days, two tails; one extending toward the sun, and the other in the opposite direction.

Comets, in passing among and near the planets, are materially drawn aside from their courses, and in some cases have their orbits entirely changed. This is remarkably true in regard to Jupiter, which seems by some strange fatality to be constantly in their way, and to serve as a perpetual stumbling block to them.

"The remarkable comet of 1770, which was found by Lexell to revolve in a moderate ellipse. in a period of about five years, actually *got entangled* among the satellites of Jupiter, and thrown out of its orbit by the attractions of that planet," and has not been heard of since.—*Herschel*, p. 310. By this extraordinary rencounter, the motions of Jupiter's satellites suffered not the least perceptible derangement;—a sufficient proof of the aëriform nature of the comet's mass.

It is clear from observation, that comets contain very little *matter*; for they produce little or no effect on the motion of the planets when passing near those bodies. It is said that a comet, in 1454, eclipsed the moon; so that it must have been very near the earth; yet no sensible effect was observed to be produced by this cause upon the motion of the earth or the moon.

The observations of philosophers upon comets, have as yet detected nothing of their nature. Tycho Brahe and Appian supposed their tails to be produced by the rays of the sun, transmitted through the nucleus, which they supposed to be transparent, and to operate as a lens. Kepler thought they were occasioned by the atmosphere of the comet, driven off by the impulse of the sun's rays. This opinion, with some modification, was also maintained by Euler. Sir Isaac Newton conjectured that they were a thin vapor, rising from the heated nucleus, as smoke ascends from the earth; while Dr. Hamilton supposed them to be streams of electricity.

"That the luminous part of a comet," says Sir John Herschel, "is something in the nature of a smoke, fog, or cloud, suspended in a transparent atmosphere, is evident from a fact which has been often noticed, viz.: that the portion of the tail where it comes up to, and surrounds the head, is yet separated from it by an interval less luminous; as we often see one layer of clouds laid over another with a considerable clear space between them." And again—"It follows that these can only be regarded as great masses of thin vapor, susceptible of being penetrated through their whole substance by the sunbeams."

Comets have always been considered by the ignorant and superstitious, as the harbingers of war, pestilence, and famine. Nor has this opinion been, even to this day, confined to the unlearned. It was once universal. And when we examine the dimensions and appearances of some of these bodies, we cease to wonder that they produced universal alarm.

According to the testimony of the early writers, a comet, which could be seen in daylight with the naked eye, made its appearance 43 years before the birth of our Saviour. This date was just after the death of Cæsar, and by the Romans, the comet was believed to be his metamorphosed soul, armed with fire and vengeance. This comet is again mentioned as appearing in 1106, and then resembling the sun in brightness, being of a great size, and having an immense tail.

In the year 1402, a comet was seen, so brilliant as to be discerned at noon-day.

In 1456, a large comet made its appearance. It spread a wider terror than was ever known before. The belief was very general, among all classes, that the comet would destroy the earth, and that the Day of Judgment was at hand!

This comet appeared again in the years 1531, 1607, 1682, 1758, and 1835. It passed its perihelion in November, 1835, and will every 75½ years thereafter.

At the time of the appearance of this comet, the Turks extended their victorious arms across the Hellespont, and seemed destined to overrun all Europe. This added not a little to the general gloom. Under all these impressions, the people seemed totally regardless of the present, and anxious only for the future. The Romish Church held, at this time, unbounded sway over the lives, and fortunes, and consciences of men. To prepare the world for its expected doom, Pope Calixtus III ordered the Ave Maria to be repeated three times a day, instead of two. He ordered the church bells to be rung at noon, which was the origin of that practice, so universal in Christian churches. To the Ave Maria, the prayer was added—"Lord, save us from the Devil, the Turk, and the comet:" and once each day, these three obnoxious personages suffered a regular excommunicaton.

The pope and clergy, exhibiting such fear, it is not a matter of wonder that it became the ruling passion of the multitude. The churches and convents were crowded for confession of sins; and treasures uncounted were poured into the Apostolic chamber.

The comet, after suffering some months of daily cursing, and excommunication, began to show signs of retreat, and soon disappeared from those eyes in which it found no favor. Joy and tranquillity soon returned to the faithful subjects of the pope, but not so their money and lands. The people, however, became satisfied that their lives, and the safety of the world, had been cheaply purchased. The pope, who had achieved so signal a victory over the monster of the sky, had checked the progress of the Turk, and kept for the present, his Satannic majesty at a safe distance; while the church of Rome, retaining her unbounded wealth, was enabled to continue that influence over her followers which she retains, in part, to this day.

The comet of 1680 would have been still more alarming than that of 1456, had not science robbed it of its terrors, and history pointed to the signal failure of its predecessor. This comet was of the largest size, and had a tail whose enormous length was more than *ninety-six millions of miles.*

At its greatest distance, it is 13,000,000 of miles from the sun; and at its nearest approach, only 574,000 miles from his center; or about 130,000 miles from his surface. In that part of its orbit which is nearest the sun, it flies with the amazing swiftness of 1,000,000 miles in an hour, and the sun as seen from it, appears 27,000 times larger than it appears to us; consequently, it is then exposed to a heat 27,000 times greater than the solar heat at the earth. This intensity of heat exceeds, several thousand times, that of red-hot iron, and indeed all the degrees of heat that we are able to produce. A simple mass of vapor, exposed to a thousandth part of such a heat, would be at once dissipated in space—a pretty strong indication that, however volatile are the elements of which comets are composed, they are, nevertheless, capable of enduring an inconceivable intensity of both heat and cold.

This is the comet which, according to the reveries of Dr. Whiston, and others, deluged the world in time of Noah. Whiston was the friend and successor of Newton: but, anxious to know more than is revealed, he passed the bounds of sober philosophy, and presumed not only to fix the residence of the damned, but also the nature of their punishment. According to his theory, a comet was the awful prison-house in which, as it wheeled from the remotest regions of darkness and cold into the very vicinity of the sun, hurrying its wretched tenants to the extremes of perishing cold and devouring fire, the Almighty was to dispense the severities of his justice.

Such theories may be ingenious, but they have no basis of facts to rest upon. They more properly belong to the chimeras of Astrology, than to the science of Astronomy.

When we are told by philosophers of great caution and high reputation, that the fiery train of the comet, just alluded to, extended from the horizon to the zenith; and that of 1774 had, at one time, six tails, each 6,000,000 of miles long; and that another, which appeared soon after, had one 40,000,000 of miles long; and when we consider also the inconceivable velocity with which they speed their flight through the solar system, we may cease to wonder if, in the darker ages, they have been regarded as evil omens.

But these idle phantasies are not peculiar to any age or country. Even in our own times, the beautiful comet of 1811, the most splendid one of modern times, was generally considered among the superstitious, as the dread harbinger of the war which was declared in the following spring. It is well known that an indefinite apprehension of a more dreadful catastrophe lately pervaded both continents, in anticipation of Biela's comet of 1832.

The nucleus of the comet of 1811, according to observations made near Boston, was 2,617 miles in diameter, corresponding nearly to the size of the moon. The brilliancy with which it shone, was equal to one-tenth of that of the moon. The envelop, or aëriform covering, surrounding the nucleus, was 24,000 miles thick, about five hundred times as thick as the atmosphere which encircles the earth; making the diameter of the comet, including its envelop, 50,617 miles. It had a very luminous tail, whose greatest length was *one hundred millions of miles.*

This comet moved, in its perihelion, with an almost inconceivable velocity—fifteen hundred times greater than that of a ball bursting from the mouth of a cannon. According to Regiomontanus, the comet of 1472 moved over an arc of 120° in one day. Brydone observed a comet at Palermo in 1770, which passed through 50° of a great circle in the heavens, in 24 hours. Another comet, which appeared in 1759, passed over 4½° in the same time. The conjecture of Dr. Halley, therefore, seems highly probable, that if a body of such a size, having any considerable density, and moving with such a velocity, were to strike our earth, it would instantly reduce it to chaos, mingling its elements in ruin.

The transient effect of a comet passing near the earth, could scarcely amount to any great convulsion, says Dr. Brewster: but if the earth were actually to receive a shock from one of these bodies, the consequences would be awful. A new direction would be given to its rotary motion, and it would revolve around a new axis. The seas, forsaking their beds, would be hurried, by their centrifugal force, to the new equitorial regions:

islands and continents, the abodes of men and animals, would be covered by the universal rush of the waters to the new equator, and every vestige of human industry and genius would be at once destroyed.

The chances against such an event, however, are so very numerous, that there is no reason to dread its occurrence. The French government, not long since, called the attention of some of her ablest mathematicians and astronomers to the solution of this problem; that is, *to determine, upon mathematical principles, how many chances of collision the earth was exposed to.* After a mature examination, they reported,—"We have found that, of 281,000,000 of chances, there is only *one* unfavorable,—there exists but *one* which can produce a collision between the two bodies."

"Admitting, then," say they, "for a moment, that the comets which may strike the earth with their nucleii, would annihilate the whole human race; the danger of death to each individual, resulting from the appearance of an *unknown comet*, would be exactly equal to the risk he would run, if in an urn there was only *one single* white ball among a total number of 281,000,000 balls, and that his condemnation to death would be the inevitable consequence of the white ball being produced at the first drawing."

We have before stated that comets, unlike the planets, observe no one direction in their orbits, but approach to and recede from their great center of attraction, in every possible direction. Nothing can be more sublime, or better calculated to fill the mind with profound astonishment, than to contemplate the revolution of comets, while in that part of their orbits which comes within the sphere of the telescope. Some seem to come up from the immeasurable depths below the ecliptic, and, having doubled the heavens' mighty cape, again plunge downward with their fiery trains,

"On the long travel of a thousand years."

Others appear to come down from the zenith of the universe to double their perihelion about the sun, and then reäscend far above all human vision.

Others are dashing through the solar system in all possible directions, and apparently without any undisturbed or undisturbing path prescribed by Him who guides and sustains them all.

Until within a few years, it was universally believed that the periods of their revolutions must necessarily be of prodigious length; but within a few years, two comets have been discovered, whose revolutions are performed, comparatively, within our own neighborhood. To distinguish them from the more remote, they are denominated the *comets of a short period.* The first was discovered in the constellation Aquarius, by two French astronomers, in the year 1786. The same comet was again observed by Miss Caroline Herschel, in the constellation Cygnus, in 1795, and again in 1805. In 1818, Professor Encke determined the dimensions of its orbit, and the period of its sidereal revolution; for which reason it has been called "*Encke's Comet.*"

This comet performs its revolution around the sun in about 3 years and 4 months, in an elliptical orbit which lies wholly within the orbit of Jupiter. Its *mean* distance from the sun is 212,000,000 of miles; the eccentricity of its orbit is 179,000,000 of miles; consequently, it is 358,000,000 of miles nearer the sun in its perihelion, than it is in its aphelion. It was visible throughout the United States in 1825, when it presented a fine appearance. It was also observed at its next return in 1828; but its last return to its perihelion, on the 6th of May, 1832, was invisible in the United States, on account of its great southern declination.

The second "Comet of a short period," was observed in 1772; and was seen again in 1805. It was not until its re-appearance in 1826, that astronomers were able to determine the elements of its orbit, and the exact period of its revolution. This was successfully accomplished by M. Biela, of Josephstadt; hence it is called *Biela's Comet.* According to observations made upon it in 1805, by the celebrated Dr. Olbers, its diameter, including its envelop, is 42,280 miles. It is a curious fact, that the path of Biela's comet passes very near to that of the earth; so near, that at the moment the center of the comet is at the point nearest to the earth's path, the matter of the comet extends beyond that path, and includes a portion within it. Thus, if the earth were at that point of its orbit which is nearest to the path of the comet, at the same moment that the comet should be at that point of its orbit which is nearest to the path of the earth, the earth would be enveloped in the nebulous atmosphere of the comet.

With respect to the effect which might be produced upon our atmosphere by such a circumstance, it is impossible to offer any thing but the most vague conjecture. Sir John Herschel was able to distinguish stars as minute as the 16th or 17th magnitude *through the body of the comet!* Hence it seems reasonable to infer, that the nebulous matter of which it is composed, must be infinitely more attenuated than our atmosphere; so that for every particle of cometary matter which we should inhale, we should inspire millions of particles of atmospheric air.

This is the comet which was to come into collision with the earth, and to blot it out from the solar system. In returning to its perihelion, November 26th, 1832, it was computed that it would cross the earth's orbit at a distance of only 18,500 miles.

It is evident that if the earth had been in that part of her orbit at the *same time* with the comet, our atmosphere would have mingled with the atmosphere of the comet, and the two bodies, perhaps, have come in contact. But the comet passed the earth's orbit on the 29th of October, in the 8th degree of Sagittarius, and the earth did not arrive at that point until the 30th of November, which was 32 days afterwards.

If we multiply the number of hours in 32 days, by 68,000 (the velocity of the earth per hour), we shall find that the earth was more than 52,000,000 miles behind the comet when it crossed her orbit. Its nearest approach to the earth, at any time, was about 51,000,000 of miles; its nearest approach to the sun, was about 83,000,000 of miles. Its mean distance from the sun, or half the longest axis of its orbit, is 337,000,000 of miles. Its eccentricity is 253,000,000 of miles; consequently, it is 507,000,000 of miles nearer the sun in its perihelion than it is in its aphelion. The period of its sidereal revolution is 2,460 days, or about 6¾ years.

Up to the beginning of the 17th century, no correct notions had been entertained in respect to the paths of comets. Kepler's first conjecture was, that they moved in straight lines; but as that did not agree with observation, he next concluded that they were parabolic curves, having the sun near the vertex, and running indefinitely into the regions of space at both extremities. There was nothing in the observations of the earlier astronomers to fix their identity, or to lead him to suspect that any one of them had ever been seen before; much less that they formed a part of the solar system, revolving about the sun in elliptical orbits that returned into themselves.

This grand discovery was reserved for one of the most industrious and sagacious astronomers that ever lived—this was Dr. Halley, the contemporary and friend of Newton. When the comet of 1682 made its appearance, he set himself about observing it with great care, and found there was a wonderful resemblance between it and three other comets that he found recorded, the comets of 1456, of 1531, and 1607. The times of their appearance had been nearly at equal and regular intervals; their perihelion distances were nearly the same; and he finally proved them to be one and the same comet, performing its circuit around the sun in a period varying a little from 76 years. This is therefore called *Halley's* comet. It is the very same comet that filled the eastern world with so much consternation in 1456, and became an object of so much abhorrence to the church of Rome.

The three periodic comets, Encke's, Biela's, and Halley's, have presented, in their recent returns, some extraordinary phenomena. The periodic time of Encke's comet appears to have been regularly *diminishing* since its discovery. The distinguished astronomer whose name it bears, after a rigorous examination of all the known causes which can produce such an effect, finally reached the conclusion that there must exist, throughout the planetary regions, a rare medium, capable of resisting the motion of the light and gaseous comets. This startling doctrine has been received with considerable favor among the learned, although it involves nothing less than the final destruction of the entire solar system. In case a resisting medium exist, no matter how small its effect on the planets and comets may be, yet since the stability of the entire system is guaranteed only on the hypothesis that the revolutions of the planets are without resistance, it follows that, sooner or later, the same effects supposed to be exhibited by Encke's comet, will be shown by every revolving planet and satellite. and each, in succession, will terminate its career by falling into the sun. Recent observations by Sir John Herschel, on the physical constitution of Halley's comet during its return in 1835, have revealed some truths which may, in the end, account for the retardation of Encke's comet, without resorting to the hypothesis of a resisting medium. He conceives that the laws of gravitation will not account for certain phenomena presented by Halley's comet, and that we will be compelled to admit the existence of a repulsive force, developed under certain circumstances, among the particles composing the tails and gaseous portions of comets.

During its late return, Biela's comet exhibited the wonderful phenomenon of an actual separation into two distinct portions. When first discovered, the comet presented its ordinary appearance, but in the course of the following month, it was found to consist of two distinct parts, each possessing all the characteristics of a comet. These fragments continued to separate from each other, while they pursued their orbitual career around the sun. This phenomenon Sir John Herschel is disposed to attribute to the same causes which are operating to diminish the periodic time of Encke's comet, and which produced such sudden and wonderful changes in the appearance of Halley's comet, during its return in 1835.

The next appearance of Biela's comet will be looked for with great interest. At this time (July, 1848), astronomers are on the look-out for Encke's comet. Our knowledge of the physical constitution of these mysterious objects, is extremely limited.

The number of comets which have been observed since the Christian era, amounts to 700. Scarcely a year has passed without the observation of one or two. And since multitudes of them must escape observation, by reason of their traversing that part of the heavens which is above the horizon in the day time, their whole number is probably many thousands. Comets so circumstanced, can only become visible by the rare coincidence of a total eclipse of the sun—a coincidence which happened, as related by Seneca, 60 years before Christ, when a large comet was actually observed very near the sun.

But M. Arago reasons in the following manner, with respect to the number of comets:—The number of ascertained comets, which, at their least distances, pass within the orbit of Mercury, is thirty. Assuming that the comets are uniformly distributed throughout the solar system, there will be 117,649 times as many comets included within the orbit of Herschel, as there are within the orbit of Mercury. But as there are 30 within the orbit of Mercury, there must be 3,529,470 within the orbit of Herschel!

Of 97 comets whose elements have been calculated by astronomers, 24 passed between the sun and the orbit of Mercury; 33 between the orbits of Mercury and Venus; 21 between the orbits of Venus and the Earth; 15 between the orbits of Ceres and Jupiter. Forty-nine of these comets move from east to west, and 48 in the opposite direction.

The total number of distinct comets, whose paths during the visible part of their course had been ascertained, up to the year 1832, was one hundred and thirty-seven.

What regions these bodies visit, when they pass beyond the limits of our view; upon what errands they come, when they again revisit the central parts of our system; what is the difference between their physical constitution and that of the sun and planets; and what important ends they are destined to accomplish, in the economy of the universe, are inquiries which naturally arise in the mind, but which surpass the limited powers of the human understanding at present to determine.

CHAPTER VIII.

THE TRANSLATION OF THE SUN AND SOLAR SYSTEM THROUGH SPACE.

Having closed a rapid survey of the individual objects constituting the solar system, we proceed to the examination of the wonderful discovery made by Sir William Herschel, and recently confirmed by the Russian astronomers, that *the sun, attended by all his planets, satellites, and comets, is moving swiftly through space.*

It will be remembered, that the sun must be reckoned among the fixed stars; and, indeed, is one of the many millions of stars composing the Galaxy, or Milky Way. So soon as the fact was ascertained beyond question, that among the fixed stars many were found, which after years of attentive examination, actually changed their relative positions in the heavens, it was not unnatural to conjecture these changes to be the effect of parallax, produced by the movement of the sun and his system of planets, in some direction through the regions of space.

It will be readily seen, that in case such a movement of the sun exists, and should be appreciable in amount, when compared with the distance of the stars, its effect would be to produce an apparent change among the relative places of the stars, in consequence of the fact that the spectator every year views them from a different point of absolute space.

The extension of the law of gravitation to the fixed stars, by the discovery of binary systems, reduced it to a certainty that the stars exerted a mutual influence over each other; and from this general attraction which each exerted over every other, it was impossible for the sun to escape. The result of this general attraction would be motion in some direction. To demonstrate the truth of this conjecture — to determine the direction, angular velocity, and actual movement of the sun and system, have been the great questions for solution during the last few years of astronomical research.

Sir W. Herschel had roughly examined this subject; and from a general examination of the proper motion of the fixed stars, concluded that the solar system was moving toward the constellation Hercules. For many years, this theory was received with comparatively little favor. The speculation was so bold, so daring, and apparently so far beyond the scope of accurate examination, that many minds were indisposed to receive it. Within a few years, however, the subject has been taken up by M. Argelander, a Russian astronomer, and the grand speculation of Herschel has become a matter of absolute science.

Argelander's general method of determining the direction of the solar motion, may be thus explained, in its general outlines. He commenced by fixing, with accuracy, the places of five hundred stars, in all the visible parts of the heavens. His own determined places of these stars were then compared with the places of the same stars determined by preceding astronomers. The old position of any star, joined with its new position, would give its direction of apparent motion, and the distance between the two places, combined with the interval between the old and new observations, would fix the rate of movement per annum.

The five hundred selected stars were then grouped into three classes, according to their annual rate of motion. The most swiftly-moving, composing the first class, were examined separately in this way. The old and new places of each star being joined, the line thus determined in position, made a certain angle with the meridian, which could easily be determined. All these angles were computed; and by an examination of their values, it was seen that their general direction indicated, that in case the proper motions of these stars were occasioned by the movement of the solar system through space, the direction of that motion must be, as Herschel had said, toward the constellation Hercules.

A point in this constellation was now selected, as the one toward which the sun was moving; and, on this hypothesis, the directions in which the stars already examined would appear to move, were accurately computed. Now in case these computed directions should in every instance coincide with the actual observed directions, it would demonstrate that the point had been well chosen, and was the true point required; while a want of coincidence would show that another trial must be made.

Thus did Argelander proceed, with incredible pains, to select and test one point after another, until he obtained one, which, better than all others, harmonized all the proper motions of his five hundred stars; and this was the point towards which, it now became certain, the sun, with all his attendants, was urging his flight.

A subsequent investigation, by M. Strüve, has confirmed Argelander's results in the most remarkable manner. Having accomplished this object, M. Strüve gave his attention to the determination of the amount of *angular motion* of the solar system, as seen from the mean distance of the stars of the 1st magnitude; and by a complex and elaborate investigation, finally ascertained, that in each year, the sun's angular motion amounted to three hundred and thirty-five thousandths of one second of arc, or this would be the angle included between two visual rays, drawn from the eye of a spectator removed to the mean distance of stars of the 1st magnitude, to the two places occupied by the sun at the beginning and close of the same year.

Having learned the value of this distance approximately, we may now convert this angular motion into linear movement, and we reach the following wonderful proposition, viz. :—*The sun, attended by all his planets, satellites, and comets, is sweeping through space, towards the star π, in the constellation Hercules, at the rate of thirty-three millions three hundred and fifty thousand miles in every year.*

Such is the latest determination, with reference to the magnificent system with which we are associated.

LAW OF UNIVERSAL GRAVITATION.

It is said, that Sir Isaac Newton, when he was drawing to a close the demonstration of the great truth, that gravity is the cause which keeps the heavenly bodies in their orbits, was so much agitated with the magnitude and importance of the discovery he was about to make, that he was unable to proceed, and desired a friend to finish what the intensity of his feelings did not allow him to do. By *gravitation* is meant, that universal law of attraction, by which every particle of matter in the system has a tendency to every other particle.

This attraction, or tendency of bodies toward each other, is in proportion to the quantity of matter they contain. The earth, being immensely large in comparison with all other substances in its vicinity, destroys the effect of this attraction between smaller bodies, by bringing them all to itself.

The attraction of gravitation is reciprocal. All bodies not only attract other bodies, but are themselves attracted, and both according to their respective quantities of matter. The sun, the largest body in our system, attracts the earth and all the other planets, while they in turn attract the sun. The earth, also, attracts the moon, and she in turn attracts the earth. A ball, thrown upward from the earth, is brought again to its surface; the earth's attraction not only counterbalancing that of the ball, but also producing a motion of the ball toward itself.

This disposition, or tendency toward the earth, is manifested in whatever falls, whether it be a pebble from the hand, or an apple from a tree, or an avalanche from a mountain. All terrestrial bodies, not excepting the waters of the ocean, gravitate toward the center of the earth, and it is by the same power that animals on all parts of the globe stand with their feet pointing to its center.

The power of terrestrial gravitation is greatest at the earth's surface, whence it decreases both upward and downward; but not both ways in the same proportion. It decreases upward *as the square of the distance*, from the earth's center increases; so that at a distance from the center equal to twice the semi-diameter of the earth, the gravitating force would be only one fourth of what it is at the surface. But *below* the surface, it decreases in the *direct ratio* of the distance from the center; so that at a distance of half a semi-diameter from the center, the gravitating force is but half what it is at the surface.

Weight and *gravity*, in this case, are synonymous terms. We say a piece of lead weighs a pound, or 16 ounces; but if by any means it could be raised 4000 miles above the surface of the earth, which is about the distance of the surface from the center, and consequently equal to two semi-diameters of the earth above its center, it would weigh only one fourth of a pound, or four ounces; and if the same weight could be raised to an elevation of 12,000 miles above the surface, or four semi-diameters above the center of the earth, it would there weigh only one sixteenth of a pound, or one ounce.

The same body, at the center of the earth, being equally attracted in every direction, would be without weight; at 1000 miles from the center it would weigh one fourth of a pound; at 2000 miles, one half of a pound; at 3000 miles, three fourths of a pound; and at 4000 miles, or at the surface, one pound.

It is a universal law of attraction, that *its power decreases, as the square of the distance increases.* The converse of this is also true, viz. *The power increases, as the square of the distance decreases.* Giving to this law the form of a practical rule, it will stand thus:

The gravity of bodies above the surface of the earth, decreases in a duplicate ratio (or as the squares of their distances), in semi-diameters of the earth, from the earth's center. That is, when the gravity is *increasing*, *multiply* the weight by the square of the distance; but when the gravity is *decreasing*, *divide* the weight by the square of the distance.

Suppose a body weighs 40 pounds at 2000 miles above the earth's surface, what would it weigh at the surface, estimating the earth's semi-diameter at 4000 miles? From the center to the given hight, is $1\frac{1}{2}$ semi-diameters: the square of $1\frac{1}{2}$, or 1.5, is 2.25, which, multiplied into the weight (40), gives 90 pounds, the answer.

Suppose a body which weighs 256 pounds upon the surface of the earth, be raised to the distance of the moon (240,000 miles), what would be its weight? Thus, 4000)240,000(60 semi-diameters, the square of which is 3600. As the gravity, in this case, is decreasing, *divide* the weight by the square of the distance, and it will give 3600)256(1-16th of a pound, or 1 ounce.

2. To find to what hight a given weight must be raised to lose a certain portion of its weight.

RULE.—*Divide the weight at the surface, by the required weight, and extract the square root of the quotient.* Ex. A boy weighs 100 pounds, how high must he be carried to weigh but 4 pounds! Thus, 100 divided by 4, gives 25, the square root of which is 5 semi-diameters, or 20,000 miles above the center.

Bodies of equal magnitude, do not always contain equal quantities of matter; a ball of cork, of equal bulk with one of lead, contains less matter, because it is more porous. The sun, though *fourteen hundred thousand* times larger than the earth, being much less dense, contains a quantity of matter only 355,000 times as great, and hence attracts the earth with a force only 355,000 times greater than that with which the earth attracts the sun.

The quantity of matter in the sun, is 780 times greater than that of all the planets and satellites belonging to the solar system; consequently their whole united force of attraction is 780 times less upon the sun, than that of the sun upon them.

The *center of gravity* of a body, is that point in which its whole weight is concentrated, and upon which it would rest, if freely suspended. If two weights, one of ten pounds, the other of one pound, be connected together by a rod eleven feet long, nicely poised on a center, and then be thrown into a free rotary motion, the heaviest will move in a circle with a radius of one foot, and the lightest will describe a circle with a radius of ten feet; the center around which they move is their common center of gravity.

Thus the sun and planets move around an imaginary point as a center, always preserving an equilibrium.

If there were but one body in the universe, provided it were of uniform density, the center of it would be the center of gravity toward which all the surrounding portions would uniformly tend, and they would thereby balance each other. Thus the center of gravity, and the body itself, would forever remain at rest. It would neither move up nor down; there being no other body to draw it in any direction. In this case, the terms *up* and *down* would have no meaning, except as applied to the body itself, to express the direction of the surface from the center.

Were the earth the only body revolving about the sun, as the sun's quantity of matter is 355,000 times as great as that of the earth, the sun would revolve in a circle equal only to the *three hundred and fifty-five thousandth* part of the earth's distance from it: but as the planets in their several orbits vary their positions, the center of gravity is not always at the same distance from the sun.

The quantity of matter in the sun so far exceeds that of all the planets together, that were they all on one side of him, he would never be more than his own diameter from the common center of gravity; the sun, is, therefore, justly considered as the center of the system.

The quantity of matter in the earth being about 80 times as great as that of the moon, their common center of gravity is 80 times nearer the former than the latter, which is about 3000 miles from the earth's center.

The secondary planets are governed by the same laws as their primaries, and both together move around a common center of gravity.

Every system in the universe is supposed to revolve, in like manner, around *one common center.*

ATTRACTIVE AND PROJECTILE FORCES.

ALL simple motion is naturally rectilinear; that is, all bodies put in motion would continue to go forward in straight lines, as long as they met with no resistance or diverting force.

On the other hand, the sun, from his immense size, would, by the power of attraction, draw all the planets to him, if his attractive force were not counterbalanced by the primitive impulse of the planetary bodies to move in straight lines.

The attractive power of a body drawing another body toward the center, is denominated *centripetal force;* and the tendency of a revolving body to fly *from* the center in a tangent line, is called the *projectile or centrifugal force.* The joint action of these two central *forces* gives the planets a circular motion, and retains them in their orbits as they revolve, the primaries about the sun, and the secondaries about their primaries.

The *degree* of the sun's attractive power at each particular planet, whatever be its distance, is uniformly equal to the centrifugal force of the planet. The nearer any planet is to the sun, the more strongly is it attracted by him; the farther any planet is from the sun, the less is it attracted by him; therefore, those planets which are the nearer to the sun must move the faster in their orbits, in order thereby to acquire centrifugal forces equal to the power of the sun's attraction; and those which are the farther from the sun must move the slower, in order that they may not have too great a degree of centrifugal force, for the weaker attraction of the sun at those distances.

The discovery of these great truths, by Kepler and Newton, established the UNIVERSAL LAW OF PLANETARY MOTION; which may be stated as follows.

1. Every planet moves in its orbit with a velocity varying every instant, in consequence of two forces; one tending to the center of the sun, and the other in the direction of a tangent to its orbit, arising from the primitive impulse given at the time it was launched into space. The former is called its *centripetal*, the latter, its *centrifugal force.* Should the centrifugal force cease, the planet would fall to the sun by its gravity; were the sun not to attract it, it would fly off from its orbit in a straight line.

2. By the time a planet has reached its aphelion, or that point of its orbit which is farthest from the sun, his attraction has overcome its velocity, and draws it toward him with such an accelerated motion, that it at last overcomes the sun's attraction, and shoots past him; then gradually decreasing in velocity, it arrives at the perihelion, when the sun's attraction again prevails.

3. However ponderous or light, large or small, near or remote, the planets may be, their motion is always such that imaginary lines joining their centers to the sun, pass over equal areas in equal times: and this is true not only with respect to the areas described every hour by the *same* planet, but the agreement holds, with rigid exactness, between the areas described in the same time, by *all* the planets and comets belonging to the solar system.

From the foregoing principles, it follows, that the force of gravity, and the centrifugal force, are mutual *opposing powers*—each continually acting against the other. Thus, the weight of bodies, on the earth's equator, is *diminished* by the centrifugal force of her diurnal rotation, in the proportion of one pound for every two hundred and ninety pounds: that is, had the earth no motion on her axis, all bodies on the equator would weigh one *two hundred and eighty-ninth part* more than they now do.

On the contrary, if her diurnal motion were accelerated, the centrifugal force would be proportionally increased, and the weight of bodies at the equator would be, in the same ratio, diminished. Should the earth revolve upon its axis, with a velocity which would make the day but eighty-four minutes long, instead of twenty-four hours, the centrifugal force would counterbalance that of gravity, and all bodies at the equator would then be absolutely destitute of weight; and if the centrifugal force were farther augmented, (the earth revolving in less time than eighty-four minutes), gravitation would be completely overpowered, and all fluids and loose substances near the equator would fly off from the surface.

The weight of bodies, either upon the earth, or on any other planet having a motion around its axis, depends jointly upon the mass of the planet, and its diurnal velocity. A body weighing one pound upon the equator of the earth, would weigh, if removed to the equator of the sun, 27.9lbs. Of Mercury, 1.03 lbs. Of Venus, 0.98 lbs. Of the moon, $\frac{1}{16}$ lb. Of Mars, $\frac{1}{2}$ lb. Of Jupiter, 2.716 lbs. Of Saturn, 1.01 lbs.

CHAPTER IX.

PRECESSION, NUTATION, ABERRATION, PARALLAX, REFRACTION.

In attempting to fix the place of any heavenly body, at a given epoch, for the purpose of ascertaining its subsequent movements, it is absolutely indispensable to know the precise changes which are affecting the points or lines to which the heavenly body is referred, and by means of which its place is determined.

The longitude and right ascension are both reckoned from the same point, viz. the *vernal equinox*, and in case this point is not fixed, then to know with accuracy the place of a star or planet referred to the vernal equinox, we must learn the precise amount of change in the place of this point of reference.

If the sun in its apparent annual motion among the fixed stars, passed over the same identical track every year, then the points in which his orbit cuts the celestial equator would be ever invariable. This, however, is not the case. The sun's path among the fixed stars, is slowly but constantly changing. If a bright star this year should happen to occupy the exact point in which the sun's path crosses the equator in the spring, at the end of one year the sun would come round and would cross the equator so as to leave that star a *little to the east.*

This apparent yearly motion of the sun westward, causes it to reach the equinox or to come to the equator earlier than it otherwise would do, and in this way brings on an equality between the days and nights, sooner than it would have come had the sun's apparent orbit been fixed. Because the sun in this way comes to the equinox at a time *preceding* its former arrival, it has been called a *precession* of the equinoxes, while in reality it is a recession or receding of the equinoctial points along the equator. We shall now in a few words trace this extraordinary phenomenon to its origin, point out its effects, and present its exact numerical value.

The swift rotation of the earth on its axis, causes a protuberance or elevation around its equatorial regions as we have already seen. This belt of matter heaped up at the equator, is subjected to the attractive energy of the sun and moon, and by their combined action exerted on this belt of redundant matter, the solid earth is made to reel slightly on its axis. Now the plane of the earth's equator produced cuts from the heavens the equinoctial, and in case this plane be in any way deranged or moved, it will cease to cut the ecliptic in its former points. It will be seen readily that whatever cause operates to displace the earth's equator, must operate to change the position of the equinoctial points.

Again: as the earth's axis is ever perpendicular to the earth's equator, it follows that every change in the position of the equator, involves a corresponding change in the position of the earth's axis. To exhibit this to the eye, take a wooden wheel, pass through its center an axis. and then let the wheel and axis float on still water. If the wheel be one half sunk below the surface of the water, the other half coming up above the surface, then will the axis cease to be vertical, and will become inclined toward the immersed portion of the wheel's rim. Repeat the experiment at any point of the rim, and it will be found that every motion of the wheel involves a corresponding motion of the axis.

The wheel represents the earth's equator, the axis that of the earth, and the surface of the still water the plane of the earth's orbit. In the long run, the effect of the combined action of the sun and moon, on the equator of the earth, causes it to cut the ecliptic in two opposite points, which move slowly backward every year, and accomplish an entire revolution in about 26,000 years. As this motion is represented exactly by the earth's axis, it follows that in the same period the pole of the equator, or north pole of the heavens, will revolve around the pole of the ecliptic.

The exact value of precession, as recently determined by M. Strüve, is 50".23449; a quantity of the utmost importance, in the nice investigations of sidereal astronomy.

In consequence of the motion of the north pole of the heavens, the bright star Polaris, now near the pole, will ultimately be left far behind, and at the expiration of about 12,000 years, the brilliant star Vega, in the Lyre, will become the polar star.

Nutation is a subordinate effect of the same general causes producing precession. It was discovered by Bradley, and is due to the joint influence of the sun and moon on the protuberant mass at the earth's equator. It varies with the configurations of the sun, moon, and moon's node, and is represented by supposing the extremity of the earth's axis to describe a minute ellipse in the heavens, in about nineteen years, while it is carried forward in its general revolution about the pole of the ecliptic. The exact numerical value of nutation, as determined by Busch, Peters, and Lundahl, is 9".2320.

Aberration.—If the light which radiates from a self-luminous body, or which is reflected from an opake one, passed instantly from one point in space to any other, however remote, then would luminous bodies actually occupy the places in space, which, to the eye, they appear to fill. This, however, is not the case. Light has been found to progress with a velocity amazing indeed, but still finite, bringing with it certain effects, which, in the present state of astronomy, cannot be disregarded. The discovery of the finite velocity of light was made by Roemer, from an attentive examination of the eclipses of the satellites of Jupiter. It will be remembered that the earth's orbit, being enclosed within the orbit of Jupiter, when the earth and Jupiter are in a straight line passing through the sun, and on the same side of the sun, they are nearer each other than when on opposite sides of the sun, by a distance equal to the diameter of the earth's orbit, or by nearly 200,000,000 of miles. It was found that those eclipses of Jupiter's satellites which occurred while the earth and Jupiter were near each other, came on earlier than the computed time; while those occurring at the time Jupiter and the earth were at their greatest distance, came on too late for the computed time. For a long time no explanation could be found for this singular phenomenon. At length it was found to depend on the relative distances of the earth and Jupiter, and was finally explained by giving to the light which comes to us from the satellites of that planet, a finite and determined velocity. As the light from the satellites is reflected light, so soon as the satellite enters the shadow of Jupiter, the source of light is cut off; and in case light moved instantly from one point to another, the eclipse would take place the moment the satellite entered the shadow of its primary. But the stream of light flowing on with a finite velocity, requires a certain time to become exhausted. When Jupiter and the earth are nearest, or in conjunction, the stream is shorter, or has a less distance to flow, by nearly 200,000,000 of miles, than when the earth and planet are in opposition, or most remote from each other. In this way it is found that light requires about sixteen minutes to cross the diameter of the earth's orbit. The velocity thus determined has been confirmed, in a remarkable manner, by Bradley's discovery of what has been called the *aberration* of the fixed stars. This is an apparent change in the places of the fixed stars, due to the fact that the velocity of light, combined with that of the earth in its orbit, causes the fixed stars apparently to describe a minute orbit, in the period of one year. Very extended and minute investigations have revealed the actual velocity of the light of the fixed stars: and this velocity is nearly, if not exactly equal, to that of reflected light as deduced from the observed eclipses of Jupiter's satellites. The numerical value of aberration, as last determined by the Russian astronomers, is 20″.50.

Parallax.—This subject has already been treated, in the chapter on the distribution and distance of the fixed stars. The effect of parallax on the place of any heavenly body, is to cause it to appear less elevated above the horizon than it would be if seen from the earth's center. The apparent places of the sun, moon, and planets, are sensibly affected by parallax; and their true places can only be obtained from their apparent places, by correcting these for the effect of parallax.

Refraction.—The light which reaches us from the heavenly bodies only comes to the eye of the observer after traversing the atmosphere, a gaseous medium, which possesses the power of causing a ray of light, while traversing it, to bend from its rectilinear path. In consequence of this bending of the rays of light, called refraction, a star or planet is seen in the direction of the straight line drawn tangent to the curved ray of light, at the point where it enters the eye; and it thus appears higher above the horizon than it really is. Thus a star or planet is seen, by the eye, while it is yet really below the horizon, in consequence of refraction. The same cause diffuses the light of day, and gives to us the twilight of morning and evening. The effect of refraction on the places of the heavenly bodies has been carefully studied, and tables have been prepared, showing the value of refraction at all elevations above the horizon, and for all changes of the thermometer and barometer.

To obtain, then, the absolute place of any heavenly body, from its apparent place, as taken by an instrument absolutely perfect, we must correct its instrumental, or observed place, for precession, nutation, aberration, parallax, and refraction. If the instrument be not absolutely perfect, then must its errors be investigated, and be allowed for, before a final reliable result can be obtained.

CHAPTER X.

THE TIDES.

THE oceans, and all the seas, are observed to be incessantly agitated for certain periods of time; first from the east toward the west, and then again from the west toward the east. In this motion, which lasts about six hours, the sea gradually swells; so that entering the mouths of rivers, it drives back the waters toward their source. After a continual flow of six hours, the seas seem to rest for about a quarter of an hour; they then begin to ebb, or retire back again from west to east for six hours more; and the rivers again resume their natural courses. Then, after a seeming pause of a quarter of an hour, the seas again begin to flow, as before, and thus alternately. This regular alternate motion of the sea constitutes *the tides*, of which there are two in something less than twenty-five hours.

The ancients considered the ebbing and flowing of the tides as one of the greatest mysteries in nature, and were utterly at a loss to account for them. Galileo and Descartes, and particularly Kepler, made some successful advances toward ascertaining the cause; but Sir Isaac Newton was the first who clearly showed what were the chief agents in producing these motions.

The cause of the tides, is the attraction of the sun and moon, but chiefly of the moon, upon the waters of the ocean. In virtue of gravitation, the moon, by her attraction, draws, or raises the water toward her; but because the power of attraction diminishes as the squares of the distance increase, the waters on the opposite side of the earth are not so much attracted as they are on the side nearest the moon.

That the moon, says Sir John Herschel, should, by her attraction, heap up the waters of the ocean under her, seems to most persons very natural; but that the same cause should, at the same time, heap them up on the opposite side, seems, to many, palpably absurd. Yet nothing is more true, nor indeed more evident, when we consider that it is not by her *whole* attraction, but by the differences of her attractions at the opposite surfaces and at the center, that the waters are raised.

That the tides are dependent upon some known and determinate laws, is evident from the exact time of high water being previously given in every ephemeris, and in many of the common almanacs.

The moon comes every day later to the meridian than on the day preceding, and her exact time is known by calculation; and the tides in any and every place, will be found to follow the same rule; happening exactly so much later every day as the moon comes later to the meridian. From this exact conformity to the motions of the moon, we are induced to look to her as the cause; and to infer that these phenomena are occasioned principally by the moon's attraction.

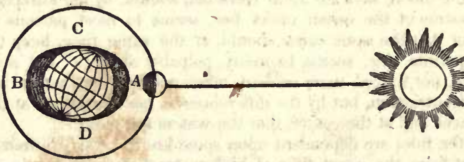
THE TIDES.

FIG. 1. FIG. 2. FIG. 3.

If the earth were at rest, and there were no attractive influence from either the sun or moon, it is obvious from the principles of gravitation, that the waters in the ocean would be truly spherical (as represented by figure 1); but daily observation proves that they are in a state of continual agitation.

If the earth and moon were without motion, and the earth covered all over with water, the attraction of the moon would raise it up in a heap in that part of the ocean to which the moon is vertical, as in figure 2, and there it would, probably, always continue; but by the rotation of the earth upon its axis, each part of its surface to which the moon is vertical is presented to the action of the moon: wherefore, as the quantity of water on the whole earth remains the same, when the waters are elevated on the side of the earth under the moon, and on the opposite side also, it is evident they must recede from the intermediate points, and thus the attraction of the moon produce *high water* at two opposite places, and *low water* at two opposite places on the earth at the same time, as represented by figure 3.

This is evident from the figure. The waters cannot rise in one place, without falling in another; and therefore they must fall as low in the horizon, at C and D, as they rise in the zenith and nadir, at A and B, as in the following figure.



It has already been shown, under the article gravitation, that the earth and moon would fall toward each other, by the power of their mutual attraction, if there were no centrifugal force to prevent them; and that the moon would fall as much faster toward the earth than the earth would fall toward the moon, as the quantity of matter in the earth is greater than the quantity of matter in the moon. The same law determines also the size of their respective orbits around their common center of gravity.

It follows, then, as we have seen, that the moon does not revolve, strictly speaking, around the earth as a *center*, but around *a point between them*, which is 80 times nearer the earth than the moon, and consequently is situated about 3000 miles from the earth's center. It has also been shown, that all bodies moving in circles acquire a centrifugal force proportioned to their respective masses and velocity. From these facts, some philosophers account for high water on the side of the earth opposite to the moon, in the following manner:

As the earth and moon move around their common center of gravity, *that part of the earth* which is at any time *turned from the moon*, being about 7000 miles farther from the center of gravity than the side next the moon, would have a *greater centrifugal force than the side next her.* At the earth's center, the centrifugal force will balance the attractive force; therefore, as much water is *thrown off* by the centrifugal force on the side which is turned *from* the moon, as is raised on the side next her by her attraction.

From the universal law, that the force of gravity diminishes as the square of the distance increases, it results that the attractive power of the moon decreases in intensity at every step of the descent from the zenith to the nadir; and, consequently, that the waters on the zenith, being more attracted by the moon than the earth is at its center, move faster toward the moon than the earth's center does: and as the center of the earth moves faster toward the moon than the waters about the nadir do, the waters will be, as it were, left behind, and thus, with respect to the center, they will be raised.

The reason why the earth and waters of our globe do not seem to be affected *equally* by the moon's attraction, is, that the earthy substance of the globe, being firmly united, does not yield to any difference of the moon's attractive force; insomuch that its upper and lower surface must move equally fast toward the moon; whereas the waters, cohering together but very slightly, yield to the different degrees of the moon's attractive force, at different distances from her.

The length of a lunar day, that is, of the interval from one meridian passage of the moon to another, being, at a mean rate, 24 hours, 48 minutes, and 44 seconds, the interval between the flux and the reflux of the sea is not, at a mean rate, precisely six hours, but *twelve minutes and eleven seconds* more, so that the time of high water does not happen at the same hour, but is about 49 minutes later every day.

The earth revolves on its axis in about twenty-four hours; if the moon, therefore, were stationary, the same part of our globe would return beneath it, and there would be two tides every twenty-four hours; but while the earth is turning once upon its axis, the moon has gone forward 13° in her orbit, which takes forty-nine minutes more before the same meridian is brought again directly under the moon. And hence every succeeding day the time of high water will be forty-nine minutes later than the preceding.

For example:—Suppose at any place it be high water at 3 o'clock in the afternoon, upon the day of new moon; the following day it will be high water about 49 minutes after 3; the day after. about 38 minutes after 4; and so on till the next new moon. The exact daily mean retardation of the tides is thus determined;

The mean motion of the moon, in a solar day. is	13°.17639639
The mean motion of the sun, in a solar day, is	0 .98564722

Now, as 15° is to 60 minutes, so is 12°.19074917 to 48′ 44″.

It is obvious that the attraction of the sun must produce upon the waters of the ocean a like effect to that of the moon, though in a less degree; for the great mass of the sun is more than compensated by its immense distance. Nevertheless, its effect is considerable, and it can be shown, that the hight of the solar tide is to the hight of the lunar tide as 2 to 5. Hence the tides, though constant, are not equal. They are greatest when the moon is in conjunction with, or in opposition to, the sun, and least when in quadrature. For, in the former case, the sun and moon set together, and the tide will equal the sum of the solar and lunar tides, and in the latter they act against each other, and the tide will be the difference.

The former are called *spring tides;* the latter, *neap tides.* The spring tides are highest when the sun and moon are near the equator, and the moon at her least distance from the earth. The neap tides are lowest when the moon, in her first and second quarters, is at her greatest distance from the earth. The general theory of the tides is this: when the moon is nearest the earth, her attraction is strongest, and the tides are the highest; when she is farthest from the earth, her attraction is least, and the tides are the lowest.

From the above theory, it might be supposed that the tides would be the highest when the moon was on the meridian. But it is found that in open seas, where the water flows freely, the moon has generally *passed the north or south meridian about three hours when it is high water.* The reason is, that the force by which the moon raises the tide *continues to act*, and consequently the waters continue to rise after she has passed the meridian.

For the same reason, the highest tides, which are produced by the conjunction and opposition of the sun and moon, do not happen on the days of the full and change; neither do the lowest tides happen on the days of their quadratures.—But the greatest *spring tides* commonly happen 1½ days *after* the new and full moons; and the least *neap tides* 1½ *days after* the first and third quarters.

The sun and moon, by reason of the elliptical form of their orbits, are alternately nearer to and farther from the earth, than their mean distances. In consequence of this, the efficacy of the sun will fluctuate between the extremes 19 and 21, taking 20 for its mean value; and between 43 and 59 for that of the moon. Taking into account this cause of difference, the highest spring tide will be to the lowest neap as 59+21 is to 43—19, or as 80 to 24, or 10 to 3. The relative *mean* influence is as 51 to 20, or as 5 to 2, *nearly.—Herschel's Astr.* p. 339.

Though the tides, in *open seas*, are at the highest about *three hours* after the moon has passed the meridian, yet the waters in their passage through shoals and channels, and by striking against capes and headlands, are so retarded that, to different places, the tides happen at all distances of the moon from the meridian; consequently at all hours of the lunar day.

In small collections of water, the moon acts at the same time on every part; diminishing the gravity of the whole mass. On this account there are no sensible tides in lakes, they being generally so small that when the moon is vertical, it attracts every part alike; and by rendering all the waters equally light, no part of them can be raised higher than another. The Mediterranean and Baltic seas have very small elevations, partly for this reason, and partly because the inlets by which they communicate with the ocean are so narrow, that they cannot, in so short a time, either receive or discharge enough, sensibly to raise or sink their surfaces.

Of all the causes of difference in the hight of tides at different places, by far the greatest is local situation. In wide-mouthed rivers, opening in the direction of the stream of the tides, and whose channels are growing gradually narrower, the water is accumulated by the contracting banks, until in some instances it rises to the hight of 20, 30, and even 50 feet.

Air being lighter than water, and the surface of the atmosphere being nearer to the moon than the surface of the sea, it cannot be doubted but that the moon raises much higher tides in the atmosphere than in the sea. According to Sir John Herschel, these tides are, by very delicate observations, rendered not only sensible, but *measurable.*

Upon the supposition that the waters on the surface of the moon are of the same specific gravity as our own, we might easily determine the hight to which the earth would raise a lunar tide, by the known principle, that the attraction of one of these bodies on the other's surface is *directly* as its quantity of matter, and *inversely* as its diameter. By making the calculation, we shall find the attractive power of the earth upon the moon to be 21.777 times greater than that of the moon upon the earth.

CHAPTER XI.

THE SEASONS—DIFFERENT LENGTHS OF THE DAYS AND NIGHTS.

THE vicissitudes of the seasons and the unequal lengths of the days and nights, are occasioned by the annual revolution of the earth around the sun, with its axis inclined to the plane of its orbit.

The temperature of any part of the earth's surface depends mainly, if not entirely, upon its exposure to the sun's rays. Whenever the sun is *above* the horizon of any place, that place is *receiving* heat; when the sun is *below* the horizon, it is parting with it, by a process which is called radiation. The quantities of heat thus received and imparted in the course of the year, must balance each other at every place, or the equilibrium of temperature would not be supported.

Whenever, then, the sun remains more than twelve hours above the horizon of any place, and less beneath, the general temperature of that place will be *above* the mean state; when the reverse takes place, the temperature, for the same reason, will be *below* the mean state. Now the continuance of the sun above the horizon, of any place, depends entirely upon his declination, or altitude at noon. About the 20th of March, when the sun is in the vernal equinox, and consequently has no declination, he rises at six in the morning and sets at six in the evening; the day and night are then equal, and as the sun continues as long above our horizon as below it, his influence must be nearly the same at the same latitudes, in both hemispheres.

From the 20th of March to the 21st of June, the days grow longer, and the nights shorter; in the northern hemisphere the temperature increases, and we pass from spring to mid-summer; while the reverse of this takes place in the southern hemisphere. From the 21st of June to the 23d of September, the days and nights again approach to equality, and the excess of temperature in the northern hemisphere above the mean state, grows less, as also its defect in the southern; so that, when the sun arrives at the autumnal equinox, the mean temperature is again restored. From the 23d of September until the 21st of December, our nights grow longer and the days shorter, and the cold increases as before it diminished; while we pass from autumn to mid winter, in the northern hemisphere, and the inhabitants of the southern hemisphere from spring to mid-summer. From the 21st of December to the 20th of March, the cold relaxes as the days grow longer, and we pass from the dreariness of winter to the mildness of spring, when the seasons are completed, and the mean temperature is again restored. The same vicissitudes transpire, at the same time, in the southern hemisphere, but in a contrary order.—Thus are produced the four seasons of the year.

But I have stated not the only, nor, perhaps, the most efficient cause in producing the heat of summer and the cold of winter. If, to the inhabitants of the equator, the sun were to remain 16 hours below their horizon, and only 8 hours above it, for every day of the year, it is certain they would never experience the rigors of our winter; since it can be demonstrated, that as much heat falls upon the same area from a *vertical* sun, in 8 hours, as would fall from him at an angle of 60°, in 16 hours.

Now as the sun's rays fall *most obliquely when the days are shortest*, and *most directly when the days are longest*, these two causes, namely, the duration and intensity of the solar heat, together, produce the temperature of the different seasons. The reason why we have not the hottest temperature when the days are longest, and the coldest temperature when the days are shortest, but in each case about a month afterwards, appears to be, that a body once heated, does not grow cold instantaneously, but gradually, and so of the contrary. Hence, as long as more heat comes from the sun by day than is lost by night, the heat will increase, and *vice versa*.

The north pole of the earth is denominated the *elevated* pole, because it is always about $23\frac{1}{2}°$ above a perpendicular to the plane of the equator, and the south pole is denominated the *depressed* pole, because it is about the same distance below such perpendicular.

As the sun cannot shine on more than one half the earth's surface at a time, it is plain, that when the earth is moving through that portion of its orbit which lies *above* the sun, the elevated pole is in the dark. This requires six months, that is, until the earth arrives at the equinox, when the elevated pole emerges into the light, and the depressed pole is turned away from the sun for the same period. Consequently, there are six months day and six months night, alternately, at the poles.

When the sun appears to us to be in one part of the ecliptic, the earth, as seen from the sun, appears in the point diametrically opposite, Thus, when the sun appears in the vernal equinox at the first point of Aries, the earth is actually in the opposite equinox at Libra. The days and nights are then equal all over the world.

As the sun appears to move up from the vernal equinox to the summer solstice, the earth actually moves from the autumnal equinox down to the winter solstice. The days now lengthen in the northern hemisphere, and shorten in the southern. The sun is now over the north pole, where it is mid-day, and opposite the south pole, where it is mid-night.

As the sun descends from the summer solstice toward the autumnal equinox, the earth ascends from the winter solstice toward the vernal equinox. The summer days in the northern hemisphere having waxed shorter and shorter, now become again of equal length in both hemispheres.

While the sun appears to move from the autumnal equinox down to the winter solstice, the earth passes up from the vernal equinox to the summer solstice; the south pole comes into the light, the winter days continually shorten in the northern hemisphere, and the summer days as regularly increase in length in the southern hemisphere.

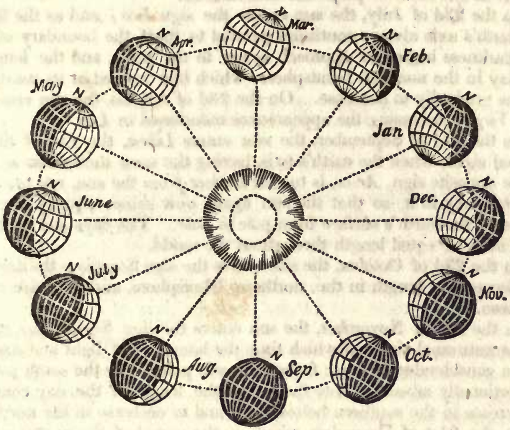
While the sun appears again to ascend from its winter solstice to the vernal equinox, the earth descends from the summer solstice to the autumnal equinox. The summer days now shorten in the southern hemisphere, and the winter days lengthen in the northern hemisphere.

When the sun passes the vernal equinox, it rises to the arctic or elevated pole, and sets to the antarctic pole. When the sun arrives at the summer solstice, it is noon at the north pole, and midnight at the south pole. When the sun passes the autumnal equinox, it sets to the north pole, and rises to the south pole. When the sun arrives at the winter solstice, it is midnight at the north pole, and noon at the south pole; and when the sun comes again to the vernal equinox, it closes the day at the south pole, and lights up the morning at the north pole.

There would, therefore, be 186½ days during which the sun would not set at the north pole, and an equal time during which he would not rise at the south pole; and 178½ days in which he would not set at the south pole, nor rise at the north pole.

At the arctic circle, 23° 27½′ from the pole, the longest day is 24 hours, and goes on increasing as you approach the pole. In latitude 67° 18′ it is 30 days; in lat. 69° 30′ it is 60 days, &c. The same takes place between the antarctic circle and the south pole, with the exception, that the day in the same latitude south is a little shorter, since the sun is not so long south of the equator, as at the north of it. In this estimate no account is taken of the refraction of the atmosphere, which, as we shall see hereafter, increases the length of the day, by making the sun appear more elevated above the horizon than it really is.

THE SEASONS—UNEQUAL LENGTHS OF DAYS AND NIGHTS.



The above cut represents the inclination of the earth's axis to its orbit in every one of the twelve signs of the ecliptic, and consequently for each month in the year. The sun enters the sign *Aries*, or the vernal equinox, on the 20th of March, when the earth's axis inclines neither *toward* the sun, nor *from* it, but *sidewise* to it; so that the sun then shines equally upon the earth from pole to pole, and the days and nights are everywhere equal. This is the beginning of the astronomical year; it is also the beginning of day at the north pole, which is just coming into light, and the end of day at the south pole, which is just going into darkness.

By the earth's orbital progress, the sun appears to enter the second sign, *Taurus*, on the 20th of April, when the north pole, *N*, has sensibly advanced into the light, while the south pole, *S*, has been declining from it; whereby the days become longer than the nights in the northern hemisphere, and shorter in the southern.

On the 21st of May, the sun appears to enter the sign *Gemini*, when the north pole, *N*, has advanced considerably further into the light, while the south pole, *S*, has proportionally declined from it; the summer days are now waxing longer in the northern hemisphere, and the nights shorter.

The 21st of June, when the sun enters the sign *Cancer*, is the first day of summer, in the astronomical year, and the longest day in the northern hemisphere. The north pole now has its greatest inclination to the sun, the light of which, as is shown by the boundary of light and darkness, in the figure, extends to the utmost verge of the *Arctic Circle;* the whole of which is included in the enlightened hemisphere of the earth, and enjoys, at this season, constant day during the complete revolution of the earth on its axis. The whole of the northern Frigid Zone is now in the circle of perpetual illumination.

On the 23d of July, the sun enters the sign *Leo;* and as the line of the earth's axis always continues parallel to itself, the boundary of light and darkness begins to approach nearer to the poles, and the length of the day in the northern hemisphere, which had arrived at its maximum, begins gradually to decrease. On the 23d of August, the sun enters the sign *Virgo*, increasing the appearances mentioned in *Leo.*

On the 23d of September, the sun enters *Libra*, the first of the autumnal signs, when the earth's axis, having the same inclination as it had in the opposite sign, *Aries*, is turned neither *from* the sun, nor *toward* it, but obliquely to it, so that the sun again now shines equally upon the whole of the earth's surface from pole to pole. The days and nights are once more of equal length throughout the world.

On the 23d of October, the sun enters the sign *Scorpio;* the days visibly decrease in length in the northern hemisphere, and increase in the southern.

On the 22d of November, the sun enters the sign *Sagittarius*, the last of the autumnal signs, at which time the boundary of light and darkness is at a considerable distance from the north pole, while the south pole has proportionally advanced into the light; the length of the day continues to increase in the southern hemisphere, and to decrease in the northern.

On the 21st of December, which is the period of the winter solstice, the sun enters the sign *Capricorn*. At this time, the north pole of the earth's axis is turned from the sun into perpetual darkness; while the south pole, in its turn, is brought into the light of the sun, whereby the whole *Antarctic* region comes into the circle of perpetual illumination. It is now that the southern hemisphere enjoys all those advantages with which the northern hemisphere was favored on the 21st of June; while the northern hemisphere, in its turn, undergoes the dreariness of winter, with short days and long nights.

CHAPTER XII.

AURORA BOREALIS

THE sublime and beautiful phenomena presented by the *aurora borealis*, or *northern lights*, as they are called, have been in all ages a source of admiration and wonder alike to the peasant and the philosopher. In the regions of the north, they are regarded by the ignorant with superstitious dread, as harbingers of evil; while all agree in placing them among the unexplained wonders of nature.

These lights, or meteoric coruscations, are more brilliant in the arctic regions, appearing mostly in the winter season and in frosty weather. They commonly appear at twilight near the horizon, and sometimes continue in that state for several hours without any perceptible motion; after which they send forth streams of stronger light, shooting with great velocity up to the zenith, emulating, not unfrequently, the lightning in vividness, and the rainbow in coloring; and again silently rising in a compact majestic arch of steady white light, apparently durable and immovable, and yet so evanescent, that while the beholder looks upon it, it is gone.

At other times, they cover the whole hemisphere with their flickering and fantastic coruscations. On these occasions their motions are amazingly quick, and they astonish the spectator with rapid changes of form. They break out in places where none were seen before, skimming briskly along the heavens; then they are suddenly extinguished, leaving behind a uniform dusky track, which again is brilliantly illuminated in the same manner, and as suddenly left a dull blank. Some nights they assume the appearance of vast columns; exhibiting on one side tints of the deepest yellow, and on the other, melting away till they become undistinguishable from the surrounding sky. They have generally a strong tremulous motion from end to end, which continues till the whole vanishes.

Maupertuis relates that, in Lapland, "the sky was sometimes tinged with so deep a red, that the constellation Orion looked as though it were dipped in blood, and that the people fancied they saw armies engaged, fiery chariots, and a thousand prodigies." *Gmelin* relates that, "in Siberia, on the confines of the icy sea, the spectral forms appear like rushing armies; and that the hissing crackling noises of those ærial fire-works so terrify the dogs and the hunters, that they fall prostrate on the ground, and will not move while the raging host is passing."

Kerguelen describes "the night, between *Iceland* and the *Ferro* Islands, as brilliant as the day," the heavens being on fire with flames of red and white light, changing to columns and arches, and at length confounded in a brilliant chaos of cones, pyramids, radii, sheaves, arrows, and globes of fire.

But the evidence of *Capt. Parry* is of more value than that of the earlier travelers, as he examined the phenomena under the most favorable circumstances, during a period of twenty-seven consecutive months, and because his observations are uninfluenced by imagination. He speaks of the shifting figures, the spires and pyramids, the majestic arches, and the sparkling bands and stars which appeared within the arctic circle, as surpassing his powers of description. They are indeed sufficient to enlist the superstitious feelings of any people not fortified by religion and philosophy.

The *colors* of the polar lights are of various tints. The *rays* or *beams* are steel gray, yellowish gray, pea green, celandine green, gold yellow, violet blue, purple, sometimes rose red, crimson red, blood red, greenish red, orange red, and lake red. The *arches* are sometimes nearly black, passing into violet blue, gray, gold yellow, or white, bounded by an edge of yellow. The *luster* of these lights varies in kind as well as intensity. Sometimes it is pearly, sometimes imperfectly vitreous, sometimes metallic. Its degree of intensity varies from a very faint radiance to a light nearly equaling that of the moon.

Many theories have been proposed to account for this wonderful phenomenon, but there seems to be none which is entirely satisfactory. One of the first conjectures on record, attributes it to inflammable vapors ascending from the earth into the polar atmosphere, and there ignited by electricity. Dr. Halley objects to this hypothesis, that the cause was inadequate to produce the effect. He was of opinion that the poles of the earth were in some way connected with the aurora; that the earth was hollow, having within it a magnetic sphere, and that the magnetic effluvia, in passing from the north to the south, might become visible in the northern hemisphere.

That the aurora borealis is, to some extent, a magnetical phenomenon, is thought, even by others, to be pretty clearly established by the following considerations:

1. It has been observed, that when the aurora appears near the northern horizon in the form of an arch, the middle of it is not in the direction of the true north, but in that of the magnetic needle at the place of observation; and that when the arch rises

toward the zenith, it constantly crosses the heavens at right angles, not to the true *magnetic* meridian.

2. When the beams of the aurora shoot up so as to pass the zenith, which is sometimes the case, the point of their convergence is in the direction of the prolongation of the dipping needle at the place of observation.

3. It has also been observed, that during the appearance of an active and brilliant aurora, the magnetic needle often becomes restless, varies sometimes several degrees, and does not resume its former position until after several hours.

From these facts it has been generally inferred, that the aurora is in some way connected with the magnetism of the earth; and that the simultaneous appearance of the meteor, and the disturbance of the needle, are either related as cause and effect, or as the *common result* of some more general and unknown cause. Dr. Young, in his lectures, is very certain that the phenomenon in question is intimately connected with electro-magnetism, and ascribes the *light* of the aurora to the illuminated agency of electricity upon the magnetical substance.

It may be remarked, in support of the electro-magnetic theory, that in magnetism, the agency of electricity is now clearly established; and it can hardly be doubted that the phenomena, both of electricity and magnetism, are produced by one and the same cause; inasmuch as magnetism may be induced by electricity, and the electric spark has been drawn from the magnet.

Sir John Herschel also attributes the appearance of the aurora to the agency of electricity. This wonderful agent, says he, which we see in intense activity in lightning, and in a feebler and more diffused form traversing the upper regions of the atmosphere in the northern lights, is present, probably, in immense abundance in every form of matter which surrounds us, but becomes sensible only when disturbed by excitements of peculiar kinds.

CHAPTER XIII.

ASTRONOMICAL INSTRUMENTS.

THE rapid introduction of telescopes into schools and academies, as means of instruction, demands some notice of the construction and modes of using these instruments. The great advantage of possessing such means of awakening interest and exciting to study, will be readily appreciated when we remember that the actual sight of an object through a telescope for even a single moment, produces an impression, through the eye, on the mind, that no labored description can ever accomplish.

There are two principal classes of telescopes, the *Refracting* and *Reflecting*. In the first class, the light from the object under examination falls on a lens of glass, and by refraction is brought to a focus, forming an image of the object which is then inspected through a powerful magnifying glass called the *eye piece*. In the reflecting telescope the light falls on a metallic speculum or highly polished mirror of such form as to *reflect* the light to a focus, where the image formed is examined with a magnifying glass. The largest telescopes which have ever been constructed, are of the *reflecting* kind, and among these may be mentioned the Great Reflector of Sir William Herschel, the diameter of whose speculum was four feet, and its focal length forty feet. A much larger one has recently been constructed by Lord Rosse, an Irish nobleman of great liberality, skill and science. The speculum of his Monster Reflector, as it has been termed, is no less than six feet in diameter! and its focal length is 54 feet. This magnificent instrument has accomplished the resolution of a great number of nebulæ into stars, which had resisted the power of all preceding instruments. The largest reflecting telescope accurately mounted in the world, is that in the observatory of Mr. Lasselle, near Liverpool. Its speculum is about 24 inches in diameter.

For many years reflecting telescopes have been little used for any other purpose than mere gazing, in consequence of their unwieldly proportions, rendering it next to impossible to mount them with sufficent accuracy and steadiness, for the nicer measures and observations of astronomy. These difficulties seem to have been successfully overcome by Mr. Lasselle, and with the accurate figure which Lord Rosse has been able to give to his large specula, reflectors may again come into competition with refractors as instruments for critical observation.

The largest and most perfect refracting telescopes, have been manufactured at the optical institute of Utzschneider and Frauenhofer, of Munich, Bavaria. Two instruments have been there constructed, with object glasses of about fifteen inches diameter. One of these is at the Imperial Russian observatory at Pulkova, near St. Petersburgh; the other is now mounted in the observatory at Cambridge, New England. The refractor of the Cincinnati observatory has an object glass of 12 inches diameter, and a focal length of 17 feet.

These large instruments are mounted with all the perfection of art. Their enormous weight is so perfectly counterpoised and balanced in every direction, as to be moved by the slightest touch of the observer. They are provided with delicate machinery, which may be attached to the telescope, and will give to it a motion such as shall exactly follow the apparent diurnal motion of any object under examination. But for this most ingenious and beautiful contrivance, with high magnifying powers, it would be next to impossible to follow the swift apparent motion of the heavenly bodies.

The *Equatorial telescope*, whether refracting or reflecting, is mounted in such way as to revolve on two principal axes. The one called the *polar axis*, is precisely parallel to the earth's axis; the other, called the *declination axis*, is perpendicular to the first in all its positions. By revolving the telescope around the polar axis, we follow the diurnal motion of the heavenly bodies; by moving the telescope around the declination axis, it is carried north or south, describing the arc of a declination circle. The two motions combined, enable the observer to direct the telescope to any point in the heavens.

The *Hour Circle*, firmly attached to the lower extremity of the polar axis, is divided into hours and minutes of time, and measures with accuracy any motion of the telescope around the polar axis. The Declination Circle, fixed to the declination axis, is divided into degrees and minutes of arc, and by Verniers, into seconds. rendering it possible to read with accuracy any motion of the telescope around the declination axis.

The *Micrometer* is an instrument so contrived as to measure, with great accuracy, the relative distances and positions which fall within the field of the telescope. There are many constructions for this purpose, among them Frauenhofer's wire micrometer holds a high rank. Two delicate *spiders' webs* are so adjusted in the focus of the eye-piece of the telescope, that they are seen distinctly, and appear, when illuminated by a small lamp, as delicate golden wires drawn across the field of view. The machinery bearing these wires is so contrived as to enable the observer to move them parallel to themselves, and also to revolve them around the axis of the telescope. Each of these motions is measured by divided scales, in the most precise manner; and such is the power of the micrometers attached to the large refractors now in use, that the semi-diameter of a spider's web may be measured with great certainty, or an inch may be divided into 80,000 equal parts.

With the micrometer, the distance and angle of position of the double stars, the diameters of the planets, of the sun and moon, are accurately measured; and a variety of delicate observations made, which could not be accomplished in any other way.

The mounting of large instruments is very expensive, when attended with all the accurate detail necessary to render them useful as means of accurate observation. The amateur astronomer, who wishes his telescope mounted merely for finding and gazing, may accomplish it at a trifling expense. (For a description of a cheap and convenient mounting, called the Parallactic Ladder, see Mitchel's Sidereal Messenger, Vol. III.)

The *Transit Instrument*, is a telescope firmly attached to an axis perpendicular to that of the telescope, and passing through its center. When this axis is so placed on permanent supports as to be exactly level, and precisely east and west, the telescope will, in revolving around its axis, describe a great circle passing north and south, or will remain in all positions in the plane of the meridian. The horizontal axis is composed of two hollow cones of brass or other material, firmly attached to the tube of the telescope, on either side. In the focus of the eye-piece, several spiders'-webs are placed at equal distances from each other, and precisely vertical in position. These are crossed at right angles by one horizontal spider's line. The number of vertical *wires*, as they are called, is generally seven. The transit instrument is used to determine the right ascension of the heavenly bodies, and the principle of its application is extremely simple, while its actual use is attended with great difficulty, and requires extraordinary care and skill.

It will be remembered, that the right ascension is measured on the equator, from the vernal equinox round through 24 hours or 360 degrees. The instant when the vernal equinox is on the meridian, is the moment marked 0 hours by a sidereal clock, or at that moment the sidereal day begins. If an object is found to cross the meridian, passing the field of the transit instrument and its central wire, at one hour seven minutes eight and three-tenths seconds, sidereal time, then will this be its right ascension in time.

To obtain the instant of crossing the middle wire, or the mean of the wires, is the critical matter in observing with the transit. The observer so places his telescope, in declination, that the star to be observed will enter the field of view near the horizontal wire. About the time of its appearance, he takes the second from the clock, and, counting the beats, notes at what beat, and fraction of a beat, the star passes each of the seven vertical wires. By adding together these times, and dividing by seven, he obtains the instant at which the star crossed an imaginary wire called the *mean of the wires.* This, corrected, for the various errors to which the clock and transit instrument are liable, will give the apparent right ascension of the object observed. The principal errors of the transit, are the following :—1st., error of *level*, arising from the fact that the horizontal axis is not precisely level, and, in case the east end is highest, the telescope will look too much west, and the reverse, if the west end be high. 2d., Error of *azimuth*, occasioned by the horizontal axis not being located precisely east and west. If the east end of the axis be a little north of east, then the telescope, looking north of the zenith, will point west of the meridian; looking south of the zenith, it will point east of the meridian. 3d., error of *collimation*, arising from a failure to make the axis of the telescope precisely perpendicular to the horizontal axis on which it revolves. This error may cause the instrument to look either too much east or west, as the axis inclines in the one or the other direction.

The *Transit Circle* is an instrument like a transit telescope, bearing on its horizontal axis a graduated circle, by means of which the position of the instrument, in declination, may be read with accuracy. Such an instrument enables the observer to determine both the right ascension and declination of the object under examination, at the same observation.

These are called fixed, or meridian instruments, because, unlike the equatorial, which may be directed to any point in the heavens, they move only in the plane of the meridian.

There are many other astronomical instruments, but our limits will not permit, in this place, a more extended notice. The only object has been, to give to the student some idea of the construction of the instruments usually found in an astronomical observatory. In mounting these telescopes for scientific use, the greatest pains must be taken to secure a firm foundation; such is the delicacy of these instruments, that nothing short of the most solid and isolated foundation, will render their results reliable. At the Cincinnati Observatory, large piers of grouted masonry are founded on the rock, and carried up to a hight suitable to receive the stone columns on which the telescopes are fixed. These piers are entirely isolated from the building and are secured from any external action.

CHAPTER XIV.

QUESTIONS ON THE MAPS; TABLES, ETC.

It has been thought unnecessary, as it is quite impracticable, to present a full set of questions on each of the constellations, and other topics treated in this volume. This would have increased the size of the volume to nearly twice its present dimensions, without increasing its value. Every judicious teacher will pursue his own plan of communicating instruction, and will never confine himself or his pupils to a set of stereotyped questions.

We present, therefore, as a mere specimen of the kind of examination which we deem important, a series of Questions on the Constellation Cygnus, Map No. 20.

Is the Swan a northern or southern constellation? In what declination is its southern limit? How far north does it extend? Between what hours of R. A. is it included? How is it bounded on the south, east, north, west? How is it situated, with reference to α Lyræ? How may the constellation be recognized in the heavens? What stars constitute the longer piece of the Cross? What stars the shorter piece? What is the name and magnitude of α Cygni? How many stars of the third magnitude are contained in the Swan, and their letter names? Where are μ, ξ, and ι situated? Where is β situated? Where are δ, θ, and κ found? What are some of the principal double stars? What are the magnitudes and colors of the components of β Cygni? What remarkable fact in the history of the components of δ Cygni? What their distance, and probable period of revolution? Give some account of the discovery of the parallax of 61 Cygni. What is the distance of this set from our system? What their period of revolution? What the sum of the masses of these stars, compared with the sun's mass? What is the distance and magnitude of the components of 61 Cygni? Why was it selected, by Bessel, for his researches for parallax? How does its swift proper motion accord with Mädler's theory of a central sun?

What remarkable nebulæ are found in the constellation? What curious phenomena have been remarked in the planetary nebulæ near δ Cygni? What may be said with regard to the magnitude and distance of these objects? Are they situated in the region of the fixed stars? How should the chart or map be held, to make its stars correspond to those in the heavens?

TABLES.

PLACES OF THE PLANETS 1ST JANUARY, 1849.

From these places, and the elements of the planets given in this work, the approximate positions of the planets may be readily computed, so as to find them at any time.

TABLE I.

Names.	Apparent R. A.			Apparent Dec.		
Mercury,	18h.	29m.	23s.	S. 24°	46′	01″
Venus,	21	33	53	S. 16	22	28
Mars,	17	03	24	S. 23	05	40
Vesta,	0	12	00	S. 6	24	00
Juno,	5	16	30	S. 0	19	00
Pallas,	16	33	18	N. 3	10	00
Ceres,	16	39	30	S. 19	18	00
Jupiter,	9	37	07	N. 15	10	03
Saturn,	23	26	33	S. 5	57	12
Uranus,	1	08	40	N. 6	37	56

TABLE II.

To change degrees, minutes, and seconds of the equator, or of right ascension, into hours, minutes, and seconds, of sidereal time.

Deg. Mi. Sec.	H. M. M. S. S. Th.	Deg. Min. Sec.	H. M. M. S. S. Th.	Degrees.	Hours.	Minutes.
1	0 4	31	2 4	70	4	40
2	0 8	32	2 8	80	5	20
3	0 12	33	2 12	90	6	0
4	0 16	34	2 16	100	6	40
5	0 20	35	2 20	110	7	20
6	0 24	36	2 24	120	8	0
7	0 28	37	2 28	130	8	40
8	0 32	38	2 32	140	9	20
9	0 36	39	2 36	150	10	0
10	0 40	40	2 40	160	10	40
11	0 44	41	2 44	170	11	20
12	0 48	42	2 48	180	12	0
13	0 52	43	2 52	190	12	40
14	0 56	44	2 56	200	13	20
15	1 0	45	3 0	210	14	0
16	1 4	46	3 4	220	14	40
17	1 8	47	3 8	230	15	20
18	1 12	48	3 12	240	16	0
19	1 16	49	3 16	250	16	40
20	1 20	50	3 20	260	17	20
21	1 24	51	3 24	270	18	0
22	1 28	52	3 28	280	18	40
23	1 32	53	3 32	290	19	20
24	1 36	54	3 36	300	20	0
25	1 40	55	3 40	310	20	40
26	1 44	56	3 44	320	21	20
27	1 48	57	3 48	330	22	0
28	1 52	58	3 52	340	22	40
29	1 56	59	3 56	350	23	20
30	2 0	60	4 0	360	24	0

TABLE III.

To change hours, minutes, and seconds, of sidereal time, into degrees, minutes, and seconds, of the equator, or right ascension.

Hours.	Degrees.	Min. Sec. Th.	D. M. M. S. S. Th.	Min. Sec. Th.	D. M. M. S. S. Th.
1	15	1	0 15	31	7 45
2	30	2	0 30	32	8 0
3	45	3	0 45	33	8 15
4	60	4	1 0	34	8 30
5	75	5	1 15	35	8 45
6	90	6	1 30	36	9 0
7	105	7	1 45	37	9 15
8	120	8	2 0	38	9 30
9	135	9	2 15	39	9 45
10	150	10	2 30	40	10 0
11	165	11	2 45	41	10 15
12	180	12	3 0	42	10 30
13	195	13	3 15	43	10 45
14	210	14	3 30	44	11 0
15	225	15	3 45	45	11 15
16	240	16	4 0	46	11 30
17	255	17	4 15	47	11 45
18	270	18	4 30	48	12 0
19	285	19	4 45	49	12 15
20	300	20	5 0	50	12 30
21	315	21	5 15	51	12 45
22	330	22	5 30	52	13 0
23	345	23	5 45	53	13 15
24	360	24	6 0	54	13 30
25	375	25	6 15	55	13 45
26	390	26	6 30	56	14 0
27	405	27	6 45	57	14 15
28	420	28	7 0	58	14 30
29	435	29	7 15	59	14 45
30	450	30	7 30	60	15 0

TABLE IV.

Showing the Latitude and Longitude of some of the principal Places in the United States, &c., with their Distances from the City of Washington.

The Longitudes are reckoned from Greenwich.

The Capitals (Seats of Government) of the States and Territories are designated by Italic Letters.

		Latitude North.	Longitude, West, in degrees.	in time.	Dist. from Wash'n.
		° ′ ″	° ′ ″	h. m. s.	miles.
Albany (Capital),	N. Y	42 39 3	73 44 49	4 54 59 3	376
Alexandria,	D. C.	38 49	77 4	5 8 16	6
Annapolis,	Md.	39 0	76 43	5 6 52	37
Auburn,	N. Y.	42 55	76 28	5 5 52	339
Augusta,	Ga.	33 28	81 54	5 27 36	580
Augusta (State House),	Me.	44 18 43	69 50	4 39 20	595
Baltimore (Battle Monument),	Md.	39 17 13	76 37 50	5 6 31.3	38
Bangor (Court House),	Me.	44 47 50	68 47	4 35 8	661
Barnstable (Old Court House),	Mass.	41 42 9	70 16	4 41 4	466
Batavia,	N. Y.	42 59	78 13	5 12 52	370
Beaufort,	S. C.	32 25	80 41	5 22 44	629
Boston (State House),	Mass.	42 21 15	71 4 9	4 44 16.6	432
Bristol (Hotel),	R. I.	41 39 58	71 19	4 45 36	409
Brooklyn (Navy Yard),	N. Y.	40 41 50	73 59 30	4 55 58	227
Brunswick (College),	Me.	43 53 0	69 55 1	4 39 40.1	568
Buffalo,	N. Y.	42 53	78 55	5 15 40	376
Cambridge (Harvard Hall),	Mass.	42 22 15	71 7 25	4 44 29.7	431
Camden,	S. C.	34 17	80 30	5 22 12	467
Canandaigua,	N. Y.	42 54	77 17	5 9 8	336
Cape Cod (Light House),	Mass	42 2 16	70 4	4 40 16	507
Charleston (College),	S. C.	32 47 0	80 0 52	5 20 3.5	544
Charlestown (Navy Yard),	Mass.	42 22	71 3 33	4 44 14 2	433
Cincinnati,	Ohio.	39 6	84 22	5 37 28	497
Columbia,	S. C.	33 57	81 7	5 24 28	500
Columbus,	Ohio.	39 47	83 3	5 32 12	396
Concord (State House),	N. H.	43 12 29	71 29	4 55 56	474
Dedham (Court House),	Mass.	42 16	71 11	4 44 44	422
Detroit,	Mich.	42 24	82 58	5 31 52	526
Donaldsonville,	La.	30 3	91 2	6 4 8	1278
Dorchester (Ast. Observatory),	Mass.	42 19 15	71 4 15	4 44 17	432
Dover,	Del.	39 10	75 30	5 2 0	114
Dover,	N. H.	43 13	70 54	4 43 36	490
Easton (Court House),	Md.	38 46 10	76 8	5 4 32	80
Eastport,	Me.	44 54	66 56	4 27 44	778
Edenton,	N. C.	36 0	77 7	5 28 28	284
Exeter,	N. H.	42 58	70 55	4 43 40	474
Frankfort,	Ky.	38 14	84 40	5 38 40	551
Fredericksburg,	Va.	38 34	77 38	5 10 32	56
Frederickton,	N. B.	46 3	66 45	4 27 0	
Frederickstown,	Md.	39 24	77 18	5 9 12	43
Georgetown,	S. C.	33 21	79 17	5 17 8	482
Gloucester,	Mass.	42 36	70 40	4 42 40	462
Greenfield,	Mass.	42 37	72 36	4 50 24	396
Hagerstown,	Md.	39 37	77 35	5 10 20	68
Halifax,	N. S.	44 39 20	63 36 40	4 14 27	936
Hallowell,	Me.	44 17	69 50	4 39 30	593
Harrisburgh,	Pa.	40 16	76 50	5 7 20	110
Hartford,	Conn.	41 46	72 50	4 51 20	335

	Latitude North.			Longitude, West, in degrees.			in time.	Dist. from Wash'n.
	°	′	″	°	′	″	h. m. s.	miles.
Hudson, ...N. Y.	42	14		73	46		4 55 4	345
Huntsville, ...Ala.	34	36		86	57		5 47 48	726
Indianapolis, ...Ind.	39	55		86	5		5 44 20	573
Jackson, ...M'pi.	32	23		90	8		6 0 32	1035
Jefferson, ...M'uri.	38	36		92	8		6 8 32	980
Kennebunk, ...Me.	43	25		70	32		4 42 8	518
Kingston, ...U. C.	44	8		76	40		5 6 40	456
Knoxville, ...Tenn.	35	59		83	54		5 35 36	516
Lancaster, ...Pa.	40	2	36	76	20	33	5 5 22.2	109
Lexington, ...Ky.	38	6		84	18		5 37 12	534
Little Rock, ...Ark	34	40		92	12		6 8 48	1068
Lockport, ...N. Y.	43	11		78	46		5 15 4	403
Louisville, ...Ky.	38	3		85	30		5 42 0	590
Lowell (St. Ann's Church), ...Mass.	42	38	45	71	18	45	4 45 15	439
Lynchburgh, ...Va.	37	36		79	22		5 17 28	198
Lynn, ...Mass.	42	28		70	57		4 43 48	441
Marblehead, ...Mass.	42	30		70	52		4 43 28	450
Middletown, ...Conn.	41	34		72	39		4 50 36	325
Milledgeville, ...Ga.	33	7		83	20		5 33 20	642
Mobile, ...Ala.	30	40		88	11		5 52 44	1033
Montpelier, ...Vt.	44	17		72	36		4 50 24	524
Monomoy Point Light, ...Mass.	41	32	58	70	1	31	4 40 6.1	500
Montreal, ...L. C.	45	31		73	35		4 54 20	601
Nantucket (Town Hall), ... Mass.	41	16	32	70	7	42	4 40 30.8	500
Nashville, ...Tenn.	36	9	30	86	49	3	5 47 16.2	714
Natchez. (Castle), ...M'pi.	31	34		91	24	42	6 5 38.8	1146
Newark, ...N. J.	40	45		74	10		4 56 40	215
New Bedford (Mariners' Ch.), ·Mass	41	38	7	70	56	0	4 43 44	429
Newbern, ...N. C.	35	20		77	5		5 8 20	337
Newburgh, ...N. Y.	41	31		74	1		4 56 4	282
Newburyport (2d Pres. Ch.), ...Mass.	42	48	29	70	52	0	4 43 28	466
Newcastle, ...Del.	39	40		75	33		5 2 8	103
New Haven (College), ...Conn.	41	17	58	72	57	46	4 51 51.1	301
New London, ...Conn.	41	22		72	9		4 48 36	354
New Orleans (City), ...La.	29	57	45	90	6	49	6 0 27.3	1203
Newport, ...R. I.	41	29		71	21	14	4 45 24.9	403
New York (City Hall), ...N. Y.	40	42	40	74	1	8	4 56 4.5	226
Norfolk (Farmer's Bank), ...Va.	36	50	50	76	18	47	5 5 15.1	217
Northampton (Mansion House), Mass.	42	18	55	72	40		4 50 40	376
Norwich, ...Conn.	41	33		72	7		4 48 28	362
Pensacola, ...Fla.	30	28		87	12		5 48 48	1050
Petersburgh, ...Va.	37	13	54	77	20		5 9 20	144
Philadelphia (Independ. Hall), ·Pa.	39	56	59	75	10	59	5 0 43.9	136
Pittsburgh, ...Pa.	40	32		30	8		5 20 32	223
Pittsfield (1st. Cong. Church), ··Mass.	42	26	59	73	17	30	4 53 10	380
Plattsburgh, ...N. Y.	44	42		73	26		4 53 44	539
Plymouth (Court House), ...Mass.	41	57	12	70	42	30	4 42 50	439
Portland (Town House), ...Me.	43	39	26	70	20	30	4 41 22	542
Portsmouth (Court House), ...N. H.	43	4	54	70	45		4 43 0	491
Poughkeepsie, ...N. Y.	41	41		73	55		4 55 40	301
Princeton, ...N. J.	40	22		74	35		4 58 20	177
Providence (Old Col.), ...R. I.	41	49	25	71	25	56	4 45 43.7	394
Quebec (Castle), ...L. C.	46	47	17	70	56	31	4 43 46.1	781
Raleigh, ...N. C.	35	47		78	48		5 15 12	286
Richmond (Capitol), ...Va.	37	32	17	77	26	28	5 9 49.9	122
Rochester (R'r House), ...N. Y.	43	8	17	77	51		5 11 24	361
Sable (Cape), ...Fla.	24	50		81	15		5 25 0	—
Sackett's Harbor, ...N. Y.	43	55		75	57		5 3 48	407
Saco, ...Me.	43	31		70	26		4 41 44	528
St. Augustine, ...Fla.	29	48	30	81	35		5 26 20	841
St. Louis, ...M'ri.	38	36		89	36		5 58 24	856

	Latitude North.	Longitude, West, in degrees.	Longitude, West, in time.	Dist. from Wash'n.
	° ′ ″	° ′ ″	h m. s.	miles.
Salem (E. I. M. Hall),..........Mass.	42 31 19	70 54	4 43 36	446
Savannah, ...Ga.	32 2	81 3	5 24 12	662
Schenectady, ...N. Y.	42 48	73 55	4 55 40	391
Springfield (Court House),.....Mass.	42 5 58	72 36	4 50 24	357
Tallahassee, ...Fla.	30 28	84 36	5 38 24	896
Taunton (Court House), ...Mass.	41 54 9	71 50	4 44 20	415
Toronto (York),...............U. C.	43 33	79 20	5 17 20	500
Trenton, ...N. J.	40 14	74 39	4 58 36	166
Troy, ...N. Y.	42 44	73 40	4 54 40	383
Tuscaloosa,....................Ala	33 12	87 42	5 50 48	858
University of Virginia,........Va.	38 2 3	78 31 29	5 14 5.9	124
Utica (Dutch Church),.........N. Y.	43 6 49	75 13	5 0 52	383
Vandalia,.....................Ill.	38 50	89 2	5 56 8	781
Vevay, ...Ind.	38 46	84 59	5 39 56	556
Vincennes,....................Ind.	38 43	87 25	5 49 40	1693
WASHINGTON (Capitol),........D. C.	38 52 54	77 1 48	5 8 7.2	—
Washington,...................M'pi.	31 36	91 20	6 5 20	146
Wheeling,............... ....Va.	40 7	80 42	5 22 48	264
Wilmington,..................Del.	39 41	75 28	5 1 52	108
Wilmington,..................N. C.	34 11	78 10	5 12 40	416
Worcester (Ant. Hall),........Mass.	42 16 9	71 49 0	4 47 16	394
York. ....Me.	43 10	70 40	4 42 40	500
York,..........................Pa.	39 58	76 40	5 6 40	87

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